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Fig. 1.—Large cold sawing machine with swivel head for cutting steel castings.

ELECTRICALLY-DRIVEN COLD SAWS.—[See page 380.]

Some Economic and Æsthetic Aspects of Electrochemistry*

A Revaluation of Values in the Light of Modern Science

By E. F. Roeber

THERE is beauty in electrochemistry. The late Ludwig Boltzmann once said that of all artists the mathematical physicist is nearest to the world's Creator in the simplicity, directness and economy of his methods; Boltzmann made this remark in appreciation of the work of Kirchhoff and Maxwell. But we can apply it with equal truth to the electronic theory of our own time, which in the simplicity of its fundamental conceptions and in the comprehensiveness of its outlook has all the elements of pure beauty. The intellect which builds the structure of the atoms of the different chemical elements out of a positive electric nucleus in association with varying numbers of negative electrons, and makes his atoms produce the desired result, is a true creator, and his model has beauty like the visible world around us.

But more beauty is hidden in electrochemistry than the mathematical beauty of electrochemical theory. The research electrochemist who works out a new process, whether it is the reduction of aluminium from its oxide, or the conversion of amorphous carbon into graphite, or the production of calcium carbide from lime and coke, or whatever else, proceeds exactly along the same methodical lines as the artist, whether he be sculptor or painter or poet. The artist must take nature as it is. But for his work he takes from nature only what his imagination tells him to be essential to the idea he has in mind. It is this selective copying of the essential from nature and this restriction to nothing but the essential that makes a work of art beautiful.

The method is exactly the same with the creative electrochemist. He cannot improve on Nature's processes and methods. All he can do is to imitate or copy Nature's processes and combine them to a certain end. But because his goal is a certain product he can select the starting materials which are essential and use nothing else, and he can select those processes which are essential and combine them into the most direct method of production, and produce only what is wanted. Artificial graphite made in the electric furnace is superior to natural graphite, because nature does not set out to make pure graphite and man can. This makes the economic value of artificial graphite; but it also makes the artificial graphite process, in the bold directness of its execution, a true work of art. Wherever a process is so designed as to reach its object in the most direct way with greatest economy, it is beautiful in the eyes of those who understand its *rationale*. This is broadly true and not restricted to electrochemistry; but the trained engineer's or scientist's intellectual eye is needed to see this type of beauty.

The thoughts on some particular aspects of electrochemistry which I want to submit to you for reflection to-night are of a cognate nature. They refer to the part which electrochemistry plays in the changes now going on in modern civilization in economic and æsthetic valuations. Our age is called an age of unrest and revolution. Whether we are really so much more restless than our ancestors is open to discussion and hard to decide. But that the scientific and concomitant engineering advances of the last century have brought an entirely new phase (in the phase-rule sense) into the play of human reactions which make up the history of mankind, is not open to question. That the effects of modern science and engineering go far beyond their spheres of immediate interest is undisputed. What then is the effect of electrochemistry on two fields apparently so remote as political economy and æsthetics?

To express the question concisely I borrow Friedrich Nietzsche's phrase of the revaluation of values. My subject is: How does electrochemistry bring about a revaluation of economic and æsthetic values? I have brought Nietzsche's name into this discussion for still another reason. Nietzsche's brilliant and, at first sight, extraordinarily daring attempt of a revaluation of ethical values for the sake of creating the "Uebermensch," is perhaps in the final analysis of its positive aspects nothing more than a robust reassertion of what was strong and healthy in the viewpoints and valuations of classic Greece and Rome, but has been lost in the last nineteen centuries to an exaggerated weak sentimentality. Nietzsche wanted to make restitution of this lost strength and health from classic Greece to modern civilization and thus create a new ethics. Now, it would seem that the effect of science and engineering on æsthetics is acting at present in the same direction in emphasizing the necessity of a return to the æsthetic viewpoint of classic Greece, as embodied in Socrates' view of the kinship of beauty and utility. It is for this reason that before speaking of æsthetic aspects of electrochemistry it is necessary to take up its economic aspects.

How are economic values being created by industrial electrochemistry? For this discussion Prof. Karl Knies's old and well-known conception is very useful: that economic value is of three kinds—place value, time value and form value. If I may use the text-book illustration, ice in winter in the Maine woods has no economic value because there is no market for it there. Brought to New York, it gets place value, because there is a demand for it in New York. Stored and sold in summer time, it gets an additional economic value—time value. Nothing has been done to the ice itself by man. The place value has been created by transportation, the time value by storing, and as we will see later these two points are of importance for the production of economic values by electrochemistry.

But for the present let us consider the third kind of economic value—form value—that is the value created by the work done by man on the materials of nature, comprising mechanical work as well as chemical changes. Any chemical reaction produces or annihilates form values, economically speaking. But what is the distinguishing characteristic feature of the form values produced by the electrochemical industries? Let us take a few typical examples.

By the electrolysis of a solution of common salt we get caustic soda and chlorine, and we work up the latter perhaps into bleaching powder. The excess of the value of the caustic soda and bleaching powder over that of common salt is the form value produced by this process. So it is in the production of calcium carbide from lime and coke, of nitric acid and nitrates from atmospheric air and so on.

The fixation of atmospheric nitrogen, representing an extreme case, is most instructive. The raw material is atmospheric air which, as such, has no economic value at all, so that we might say that in the production of nitrate from air the economic efficiency becomes infinitely high. It sounds very well to speak of a process with an infinitely high economic efficiency, but if we stop to remember that exactly this process which is now worked with fair financial results in Norway proved a commercial failure some ten years ago in Niagara Falls, it is evident that our consideration must have been in some way so one-sided as to be misleading.

Why was fixation of atmospheric nitrogen a failure at Niagara Falls and why is it a success in Norway? Not primarily on account of the process, because the Bradley-Lovejoy process worked with about the same technical efficiency as the Birkeland-Eyde process, though the apparatus was considerably more complicated. No, the decisive element which caused failure at Niagara Falls and success in Norway, is the cost of electric power, which is three to five times lower in Norway than at Niagara Falls. And this brings us right to the root of the whole matter.

In discussing the economic value of some electrochemical products we have so far, in a one-sided way, compared only the value of the starting materials and of the end products; but we have entirely neglected the fact that in these cases we have to do not only with materials as such, but rather with the storage of energy in materials. The form value of many products of electrochemical industries is essentially due to their high energy content. A large amount of chemical energy is stored in electrochemical products; it is latent under ordinary conditions, but it may be gotten out wherever and whenever necessity arises, and this fact makes them useful and economically valuable.

Let us carry this consideration a little further by making use of the conception that the energy of a given system may be considered as the product of two factors—the capacity factor and the intensity factor, to use the terms of Ostwald. The total amount of energy remains the same, however the two factors may be changed, if only their product remains the same. But for the engineering applications it makes an enormous difference whether we make the capacity factor small and the intensity factor large or the former large and the latter small.

In case of a waterfall the amount of water passing over the fall in a certain time is the capacity factor, the height of the fall is the intensity factor. The engineering requirements for the development of a waterfall with little water and a high fall are very different from the case of a lot of water with a small fall, though the energy may be exactly the same in both cases.

In the case of electrical energy the current passing in a certain time, measured in coulombs, is the capacity factor, the pressure in volts is the intensity factor. For electric power transmission we make the intensity factor, the voltage, as large as possible, in order to decrease the transmission loss.

In the case of electrochemical products, the weight of the materials is the capacity factor, the specific energy stored in them per unit of weight is the intensity factor. If we make the latter high, if we store a lot of energy in a little matter, it will again be favorable in reducing the cost of transportation.

Now the element of transportation brings us to the conception of the place value of electrochemical products. If their form value is due to their high energy content, their place value is due to the possibility of chemical power transmission by material transportation of electrochemical products. Those products of the electrochemical industries which are characterized by a high specific energy content are the principal medium of chemical power transmission.

There are two points of chemical power transmission to be specially emphasized. One is that it is not bound to a fixed route. It requires no line wires. It makes use of the ordinary transportation facilities for materials—railways, ships, etc. This is important, as it opens fields for chemical power transmission where electrical power transmission fails. For instance, there are still very large areas in this country, Canada and elsewhere which are so little populated that it would not pay to erect an electric transmission system to provide electric current for lighting. Here acetylene lighting is of supreme importance. And acetylene lighting is a case of chemical power transmission. At Niagara Falls the electric furnace produces calcium carbide from lime and carbon, and chemical energy is thus stored in the carbide which is transported with its energy to any place where acetylene is required for lighting.

If transportation creates place value, storage creates time value. The use of chemical energy after it has been transmitted is not bound to a certain time and that is the second important feature of chemical power transmission. With electrical energy which cannot be stored as such, it is necessary to use the transmitted energy at once or to provide special means for storing it. In this respect chemical power transmission differs essentially from electric power transmission and is superior to it. Chemical energy is in itself essentially stored latent energy, and is used, therefore, in connection with other systems of power transmission for storage purposes, as in the case of storage batteries for electric power systems. The time value of calcium carbide is due to the fact that we can store it and can produce the acetylene just at the moment when it is needed for lighting.

There is a long list of electrochemical products which may be considered from the viewpoint of chemical power transmission. In bleaching powder we transmit the possibility of producing a bleaching or a disinfecting liquid whenever and wherever it is needed. In the series of peroxides we transmit their avidity to give off an atom of oxygen when and where we want it, or the reaction caused by it.

As pretty and concrete an illustration of chemical power transmission as we may wish is found in Hans Goldschmidt's ingenious aluminothermic reaction. The heat of reaction of aluminium and oxygen in forming alumina is relatively very high per unit of weight of aluminium. This is just the reason why the economical reduction of aluminium from alumina did not succeed until electrolysis was resorted to. Now, the fundamental idea of the aluminothermic method is that we have in metallic aluminium a medium which gives us by combination with oxygen a large amount of energy wherever or whenever needed. In thermit, the mixture of aluminium and iron oxide, we transport essentially the capability of producing at any place and at any time highly superheated molten steel for welding rails, for making repairs, and so on.

Again, in the new and important Norwegian nitrate industry we have an example of what we may call international chemical power transmission, as the economical value of Norsk saltpeter depends on its easy transportation by ship to other countries. Thus we have at the same time creation of economic values in Norway by building up a new and important industry, and creation

* Presidential address delivered before the American Electrochemical Society on April 16th, 1914.

of economic values in other countries by using the Norsk saltpeter to further agriculture.

I have dwelt on the relation of electrochemistry to chemical power transmission at such length because so many electrochemical products can be considered from this viewpoint. But it would be wrong to think that the whole of electrochemistry can thus be viewed. There is quite a number of very important electrochemical products in which, with no stretch of imagination, I am able to detect the elements of chemical power transmission. But in all such cases the form value is high.

In the case of aluminium we have the aspect of chemical power transmission only in the aluminothermic reaction, which though big in itself, uses only a small amount of the total output of aluminium. In cooking utensils, in line-wire construction and other applications it is simply the mechanical and electrical properties of aluminium which count and which give it a high form value.

In electrolytic copper refining, the oldest and certainly one of the biggest electrochemical industries, the increase of form value is remarkable. It is a double one. First, the gold and silver are recovered; second, the copper itself is considerably increased in form value, due to its greater purity and resulting higher electric conductivity.

All those products of electrochemical industries which have nothing to do with chemical power transmission have a high form value, and must have it, because otherwise it would not pay to use an electrochemical process in view of the high cost of electrical power. Hence, the well-known axiom that in all such applications the use of electrochemical processes should be restricted as much as possible to the finishing touches, that is, to the refining of a comparatively advanced product.

In addressing the American Electrochemical Society I need hardly show at length how this creation of economic values by the electrochemical industries has affected and is affecting modern civilization in its various phases. What was waste before and what was considered a nuisance, becomes valuable. When the early Colorado gold seekers discovered tungsten ore in Boulder county they cursed it, as it was not what they wanted. From their cursed "heavy black sand" electrochemistry has given to civilization ferro-tungsten and the tungsten lamp. From culm, the waste material of the anthracite coal mines, Acheson has given to the world artificial graphite with its immense applications. Then there are the grand electric-furnace industries of artificial abrasives in use in so many walks of life. And so I could go on through the list of electrochemical products down to Cottrell's electrostatic process of recovering values from obnoxious smelter fumes. Only this, however, I should add, that electrolytic copper refining, itself made possible by the dynamo, has paid back its debt to electrical engineering, and by furnishing high-conductivity copper has made modern electric power transmission possible. And as we have seen, in chemical power transmission electrochemistry has brought into modern civilization an absolutely new element by which what is now waste power is being scattered all over the world to build up industries, to further agriculture with fertilizers, to light cities with acetylene, to aid public health with bleaching powder, and to affect civilization in general in its most heterogeneous aspects. That electrochemists as true creators are bringing about a revaluation of economic values there can be no doubt. But what has electrochemistry to do with æsthetics?

If beauty is perceived through our senses, the first question is: How has modern engineering affected our senses? And the answer is simply that modern engineering has given us artificial senses in addition to our natural senses. In the old days when the few pieces of apparatus in physical and chemical laboratories were home-made affairs, it was said that experimental physicists and chemists should be able to see with their ears and hear by touch, smell with their tongues and measure temperatures with their eyes. Now modern engineering has given us instruments and apparatus which really represent new senses and which are available to a much more general public. And what is more, our artificial senses can be repaired or replaced by new and better ones and they give us permanent records.

I am not stretching the meaning of the term senses in speaking of instruments as artificial senses. To the electrical engineer the readings of the voltmeter and wattmeter are as real and as true indications of the outside world as though he put his head out of the window to feel whence the wind blows. Pyrometers give as real, though much more exact indications of temperature, as the touch by hand of a hot body or the trained eye of the furnace man. The photographic camera is a new artificial eye that preserves the record of what it sees. Successive photographs put together in a moving-picture enable us to crowd into a period of five minutes what may have happened in a year. We can see crystals grow and plants grow. The electric oscillograph gives us a record that permits us to see at leisure transient phenomena that happen in portions of a second and study over them for hours. The telephone stretches the ability of the human ear so that it can hear in Denver what is said in New York. And if we hear our children of three or four years talk to us over the long-distance telephone in such a self-evident, matter-of-fact way as though they were sitting on our knees, we cannot escape the conclusion that a new generation is rising to which the perception of the outside world comes through new senses, and which consequently looks at the world with new eyes. What has electrochemistry to offer to this new generation in æsthetic ideals?

It seems to me that the fundamental contribution which electrochemistry has to make to æsthetics is to carry to its last consequence the principle that waste can never be beautiful. Of course, this principle is as old as art. Waste of words in a work of literature, waste of lines or colors in pictures, waste of space in architecture, have always been considered the opposite of beautiful. But the growing multiplicity of our sensual knowledge, due to the magnified and projected extension of our senses, forces us to see waste where our ancestors saw beauty and had a right to see beauty.

Permit me to concentrate my remarks on the one subject that is uppermost in this connection in the minds of American electrochemists—the question of the power development of Niagara Falls. I use it as a clear-cut example of what is meant by revaluation of æsthetic values by electrochemistry. The magnificent group of electrochemical industries of Niagara Falls, which are the pride of every American electrochemist and should be the pride of the whole American nation, suffers seriously from the power famine due to the cessation of power development by international agreement between the United States and Canada. This agreement is based on the alleged will of the people of both countries to have the falls preserved as a scenic spectacle on the principle of conservation of natural beauty. The battle cry is conservation of natural beauty for the people.

The counter-argument has been made that the natural-beauty conservationists want to conserve something that no longer exists. With this I agree, but I hesitate to agree with the expression usually given to this argument, namely, that if Niagara Falls could be preserved in its original magnificence, it would be worth while, but that Niagara as a majestic spectacle has never belonged to the present generation, that its beauty had been given up to noisy and offensive exploitation long before the first power station was erected.

This may be true, but it seems to me that this argument does not reach the root of the matter. The beauty of Niagara Falls, like all beauty, is subjective in the onlooker. The question is simply: What do we see when we stand at the brink of Niagara Falls?

Our ancestors, who knew nothing of the principle of conservation of energy, of transformation of different forms of energy into each other, looked simply at the material side of the Falls and saw beauty and had a right to see beauty. And if we force ourselves into such a one-sided attitude of mind we can still see beauty.

But if we stand as modern men at the Falls with a free attitude of mind, we don't see simply water, we see power. We see the possibilities of using this power for electric power transmission for lighting, traction and industrial purposes on a wider area. We see the even greater possibility of storing this power in electrochemical products and utilizing them all over the land in all walks of life. If we look at the Falls with this attitude of mind, which is the natural one for us, every cubic foot of water that goes thundering over the Falls unutilized appeals to us as waste and nothing but waste.

Now waste can never be beautiful. If the artist's selection of the essential and nothing but the essential makes a work of art beautiful, anything that strikes our imagination as waste must prevent æsthetic enjoyment. If we could look at Niagara Falls with the eyes of our ancestors it would be different; but in full possession of our extended senses which an engineering age has given us, the Falls of Niagara—as much of them as is not utilized—must simply impress us as a waste of immense proportions.

And the very element of bigness, which was an element of beauty to our ancestors, has necessarily become to us the reverse, emphasizing only more emphatically the criminal negligence of letting waste on such a tremendous scale go on. Undeveloped Niagara Falls remains spectacular, even to the modern man, but it is no longer beautiful.

The perverse mind of Nero could enjoy the spectacle of Rome burning. Children and fools might naively delight in a conflagration that would consume for spectacular purposes a million tons of coal a week. We let the equivalent waste go on in water-power and hear it called saving beauty for the people.

But there is little use in arguing in æsthetic matters. All we can really do is to make people see for themselves, use their own senses, all of them, their natural ones and their artificial ones. This is what engineering development tends to do every day; and we can rest assured that, as certainly as day follows night, a new generation is rising that will use its senses, all of them, and make its own æsthetics and enforce it.

And when that time has come and people look at the Falls of Niagara running dry, their imagination will reveal to them immense beauty, health, wealth scattered by electrical and chemical means all over the country, while the grandeur of the whirlpool rapids, unchanged and undiminished, will have a higher æsthetic value, a deeper meaning of beauty than it can possibly have for us. The world will then smile at the æsthetic scruples of so many well-meaning people and will wonder what all that talk of saving Nature's beauty was about.

The Kinematograph in Research

In an extremely interesting lecture before the Fränkisch-Oberpfälzischer Section of the Verein deutscher Ingenieure [*Zeitschrift des Ver. deut. Ing.*, 58 (1914), 268], Dr.-Ing. Hanz Goetz outlined the part kinematography had played in scientific and technical research and suggested some of the things that may be expected of it in the future. After an introduction giving statistics, describing apparatus, and outlining the history of the invention, the lecture takes up the position of moving-picture photography among the means of reproducing phenomena to the census. It differs from other means, in that it correlates two of the basic quantities that physics deals with, time and extension in space.

The most obvious way in which the kinematograph may act as an aid to science is in recording rare phenomena, such as scenes in the life of seldom seen or difficultly accessible animals, unusual surgical operations, etc.—fields in which considerable success has been attained. Its usefulness only begins here, however. Just as the scale of objects may be varied when they are represented graphically, so the time scale of actions may be changed when they are represented by the kinematograph. By an increase in speed, Prof. Pfeffer, of Leipzig, has been able to reproduce in three minutes a ten-day period of growth of a horse-chestnut twig; pictures for this reproduction were taken at five-minute intervals. A large field for the study of the growth of both plants and animals is thus opened up. Just as slow motions can be hastened so that it is possible to see the total effect in a truer perspective, so it is possible to retard and analyze quick movements, and the limits are only those of the speed with which the pictures can be taken. With the most refined mechanical devices it is not possible to take more than 250 pictures per second, but by illuminating the moving object with regularly succeeding electric sparks and photographing on a film moving continuously rather than intermittently, it was found possible to increase the number of exposures to 2,000 per second. Bull, for example, has made valuable studies of the flight of insects in this manner.

From an engineering point of view the kinematograph has been most useful in studying projectiles and their effect on armor plate. Much higher frequencies had to be used than Bull obtained, and the apparatus employed differed from his in not using a mechanical interrupter; in series with the illuminating spark-gap was a large condenser, and in parallel with it a small one; the large condenser is charged by an induction machine, and when it is discharged the small condenser is alternately charged and discharged across the gap. The period of the alternations can be judged with fair accuracy by the tone. Since an explosion can take place in the 5/1,000th part of a second, the speed of 9,000 to 50,000 exposures per second, obtained by this method, is sufficient to furnish interesting results. Since it is obviously impossible to have the camera near the object photographed, a special arrangement is used.

The kinematograph can also be used for making quantitative measurements of movements. The fall of a body has been studied by photographing on the same film the falling object and the hand of a chronograph, and in the same way the action of a steam hammer has been timed.

In these lines the kinematograph has just begun to be developed, and offers great possibilities in solving problems dealing with time and space in fields as wide apart as engineering and biology, and makes possible the study of motions so slow that it has hitherto been impossible to form conception of their whole meaning, or so fast that it has been almost impossible to form any conception of them at all.—*Journal Engineering and Industrial Chemistry.*

The skull recently exhumed and regarded as Schiller's by Prof. von Froriep, compared with Dannecker's statue of Schiller.

The Face and the Skull*

The Scientific Reconstruction of the Features of the Face from the Underlying Bone

By Prof. Kollmann

The finished portrait bust of the woman of Auvernier.. A reconstruction on scientific principles, with finishing touches by Buechly.

THE anatomist is sometimes called upon to construct a lifelike picture of a human face from the data furnished by the skull or, conversely, to identify the skull of a deceased person by means of portraits of the same person when living. In the celebrated controversy regarding Schiller's skull the problem was to select, with the aid of portrait busts and a death mask of the poet, the genuine skull from among a number of skulls found in the same vault of the cemetery at Weimar. In 1826, when it became necessary to empty this vault, the coffins were found so badly decayed that Schiller's could not be recognized. The twenty-three skulls taken from the vault were compared with the only known death mask of Schiller, and the largest skull was decided to be Schiller's, by the unanimous verdict of a large number of persons.

Subsequently a second death mask was found, in the Weimar library. The anatomist Welcker compared the skull with both masks and came to the astonishing conclusion that it corresponded with neither, and consequently could not be the skull of Schiller. This view was not generally accepted and a lively but fruitless controversy was carried on from 1884 to 1887. Twenty-five years later, Prof. von Froriep made another exploration of the vault and found a skull which he maintains to be the genuine skull of Schiller, basing his opinion on convincing proofs which he has set forth in a recently published book.

The method of comparison employed by Welcker has since proved its value in many similar cases. Instead of contenting himself with mere ocular comparison of the skull and the mask, Welcker made profile drawings of both, and fitted the profiles together. In this method, it is necessary to know the exact thickness of the fleshy parts. The approximate thickness, at each point of the profile, can be obtained from measurements of suitable cadavers, but the laws of facial conformation vary between wide limits, conditioned by age, sex and weight, all of which must be taken into consideration. The difficulty of the problem and the necessity for employing every available auxiliary to its solution, are illustrated by the following example.

For a great many years a skull, supposed to be that of Raphael, was preserved in the San Luca Academy in Rome. In 1833, a society of artists searched the Pantheon for the lost tomb of Raphael (who died in 1520) and succeeded in finding it. The tomb contained a complete skeleton, including the skull, a cast of which was made and preserved in the Pantheon.

The Auvernier skull, showing the little plaster pyramids employed in reconstructing the face.

The documentary evidence that this skeleton was Raphael's was corroborated by Welcker, by the following method: Two profile photographs were made of the skull cast, and the thickness of the flesh at every point, deduced from measurements of suitable cadavers, was marked off on these profiles. An attempt was then made to reconstruct the facial contour on this foundation, with the aid of the Uffizi portrait of Raphael, which was painted by the artist's own hand. Welcker, with the collaboration of an artist, experienced no difficulty in constructing an outline that bore a striking resemblance to the Uffizi portrait. The profile of the San Luca skull, on the contrary, was found altogether incompatible with the portrait. This skull, so long regarded as Raphael's, has since been proved by documentary evidence to be that of another person.

The same method has been applied, with complete success, to the skulls and portraits of the philosopher Kant, the musical composers Haydn and J. S. Bach, and other celebrated persons.

A different method must be employed in constructing a lifelike representation from the skull of a person of whom no portrait or death mask exists. Such problems are presented by the skulls of extinct human races. We desire to know how our ancestors looked, but their skulls give us no definite impression of their appearance in life. The most expert archæologist cannot, in his mind's eye, transform a skull into a lifelike image of a man who lived in the stone age or bronze age, 6,000 or 8,000 years ago. The transformation must be a material one, accomplished by modeling the flesh on the bones. The following example shows how this can be done:

In 1878, a skull was found, with some implements of stone and bone, in a pile dwelling at Auvernier, on the Neuenburg Lake. The skull, which was in fairly good condition, was evidently that of a woman about 30 years old, belonging to the brachycephalic or white race of Europe. The short and broad face, characteristic of this type, was very strongly accentuated in the skull, which for this reason was particularly suitable for a reconstruction of the type.

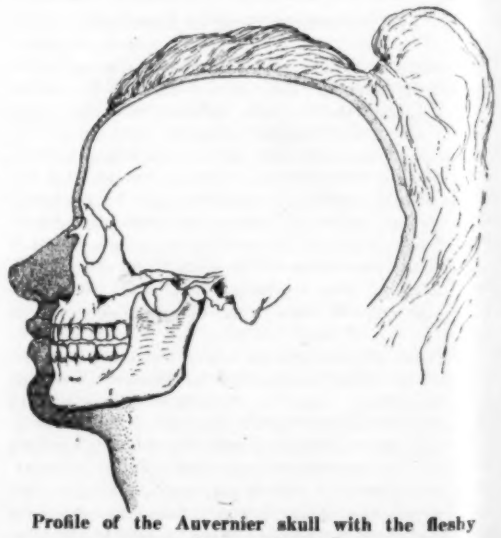
The normal thickness of the flesh at numerous points in the median line and on the sides of the face was deduced from data already collected, combined with specially made measurements of eight female cadavers. To each of the corresponding points of a plaster cast of the Auvernier skull was affixed a little plaster pyramid, the height of which was equal to the normal thickness of the flesh at that point. Some of these reference points and plaster pyramids are shown in the accompanying illustrations.

The thickness of flesh at the selected points of the cadavers was measured by means of a needle, mounted on a wooden handle and surrounded, at its base, by a rubber disk less than one half inch in diameter. The needle, previously blackened over a candle flame and oiled, was thrust through the flesh with a screwing

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Kosmos*.

Portrait of Raphael, compared with profile obtained by applying normal depths of flesh to skull.

Skull of the Neolithic woman of Auvernier with the fleshy parts reconstructed.



Profile of the Auvernier skull with the fleshy parts reconstructed.

motion (to prevent the formation of a conical depression in the skin) until its point touched the underlying bone. In this process, the lamp-black was rubbed off that part of the needle that penetrated the flesh. After the needle was withdrawn, the length of the bright portion was carefully measured to 1/100-inch with a scale and magnifying glass.

After all of the little pyramids, representing the thickness of the flesh at the selected points, had been affixed to the plaster cast of the skull, they were connected by a layer of clay, the surface of which was flush with their tips. The rough reconstruction of the face and head thus obtained was finished by an artist, Herr Buechly, who also supplied the hair and neck. Thus was produced a lifelike portrait bust of the woman of Auvernier.

Self-Contained Portable Electric Mine Lamps*

Gain in Safety, Convenience and Current Cost, as Compared with Oil Lamps

By H. O. Swoboda

It is a well-known fact that a considerable number of mine explosions with their enormous losses of life and property are caused by defects and improper handling of the so-called miners' safety lamps, built on the Davy principle. The Bureau of Mines, for instance, mentions in one of its reports that at least two disasters in this country in 1912 were caused in this manner, killing more than a dozen men, and the Prussian government states that during the decade from 1902 to 1911 at least 27 per cent of all explosions in the anthracite mines are to be blamed on these lamps. Therefore, it is only natural that attempts to develop a portable *electric* safety lamp were made quite some time ago. Satisfactory results, however, have only been obtained since the carbon filament lamps were superseded by the tungsten lamps. Owing to their high economy in current consumption they permit the reduction of the battery to such an extent that the weight and size of the portable lamp does not prevent the miner any more from moving around freely in performing his duties.

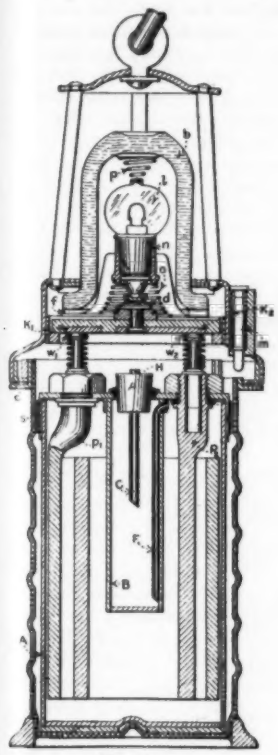


Fig. 1.

Fig. 2.

Fig. 3.

Fig. 4.

Fig. 5.

Fig. 6.

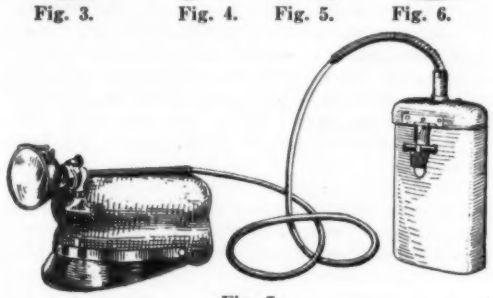


Fig. 7.

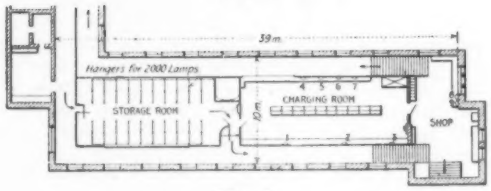


Fig. 8.

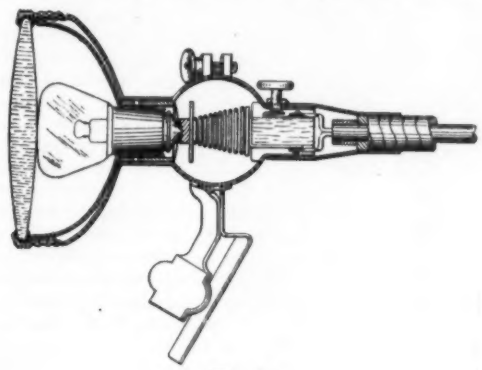


Fig. 9.

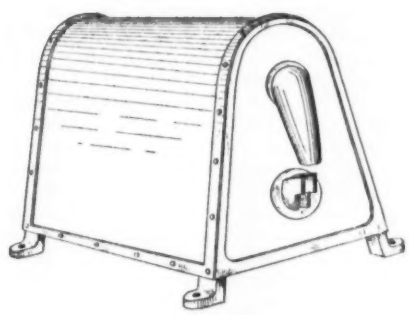


Fig. 10.

GENERAL REQUIREMENTS.

Electric safety lamps must answer the following requirements:

Absolute safety against ignition of mine gases;

Uninterrupted production of a steady and sufficient amount of light for at least one shift;

Absolutely foolproof design.

Besides this, it is essential

To have a simple and durable construction;

To keep the weight at a minimum;

To facilitate the charging and inspecting of the battery.

Safety.—Careful experiments conducted by the Bureau of Mines in Pittsburgh and also at Gelsenkirchen, Germany, have shown that the only source of danger in a portable electric lamp is the glowing filament of the incandescent lamp.

Sparks obtained by the breaking and establishing of the electric circuit are not of sufficient strength to ignite mine gases, owing to the low voltage and amperage of the batteries used, as long as the maximum short-circuiting current of these batteries does not exceed

100	amperes	for	batteries	with	not	more	than	2.5	volts
85	"	"	"	"	"	"	"	4.0	"
65	"	"	"	"	"	"	"	5.0	"
45	"	"	"	"	"	"	"	6.0	"

Therefore it is not necessary to provide special protection against sparking on the switch and on the connections between battery and lamp.

As the filament under normal conditions is operated in a vacuum and enclosed in a glass bulb, the danger of igniting mine gases exists only in case this bulb is smashed without the filament being broken at the same time, so that the latter continues to glow until it burns out. Several absolutely safe methods can be employed to prevent the filament from glowing after the bulb has been broken, and one method which has been in actual use for a number of years will be described in the course of the paper.

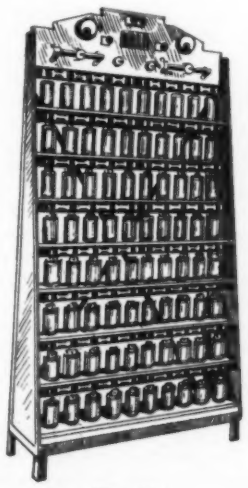


Fig. 11.

Steady and Sufficient Light.—The miners' *old* safety lamps furnish a flickering light of about 0.8 candle-power capacity, which rapidly decreases during the shift to about one half. This is not sufficient light for the miner to perform his work satisfactorily, and, according to the investigations made by Dr. T. Lister of Llewellyn, England, is the principal cause of the special eyesicknesses (miner's nystagmus) with which miners become affected. For this reason it was considered advisable to equip the *electric* mine lamps with incandescent lamps of at least 1.5 candle-power.

The only source of electrical energy which will produce this amount of light satisfactorily for at least one shift, or approximately ten to twelve hours, is the storage battery, primary batteries for such an output being entirely too large for use in portable equipments. Years of development have resulted in fairly satisfactory batteries, and it seems, in the present state of the art, that the lead cell, regardless of its weight, on account of its comparatively high voltage and slow drop in voltage while discharging, is the most suitable type.

Foolproof Design.—Miners' lamps are exposed to extremely rough handling by inexperienced hands and the least mechanical or electrical weaknesses are liable to result in a failure to supply light. The following are about the most important points which must be observed in a successful lamp:

The lamp must be locked so that the miner absolutely cannot get at any part of the mechanism.

It must burn in any position, even under water, and if dropped on solid material such as rocks, iron or cement from a height of several feet must continue to operate.

The incandescent lamp bulb must be thoroughly protected so that it is almost impossible to break it.

The electrolyte of the battery must not leak out.

That constructions of this character are possible, and in actual use, will be shown later on.

LAMP DESIGNS.

During the year 1912 prizes were offered by the British government for the best portable electric mine lamp, and not less than 197 applicants entered into competition and submitted samples. After careful tests, extending over several months, the first prize of $3,000 was awarded to the makers of the "Ceag" lamp described in this paper. Since this lamp has also been accepted by practically all other European governments and was the first lamp approved by the Bureau of Mines, answering all requirements, and still remains to-day the only approved *hand* lamp, it might be well to study its construction carefully.

* Paper read before the American Institute of Electrical Engineers, Pittsburgh, Pa., under the auspices of the Committee on Use of Electricity in Mines, and published in the *Proceedings* of the Institute.

Fig. 2 gives an idea of the general appearance of the lamp. The incandescent lamp is covered by a heavy glass dome, which is protected by four heavy steel rods held together by a sheet steel roof. A substantial hook is attached to this roof, so that the miner can either stand the lamp on the ground or hang it to a post in the immediate neighborhood of his working place. The bottom part, made of heavy corrugated galvanized sheet steel, contains the storage battery. By turning the upper part on the lower, the miner can turn the light on and off.

The construction of the lamp is easily understood from a section shown in Fig. 1.

The incandescent lamp *l* rests in a socket *n*, which is pressed upward by a spiral spring *o* against another spring *p* between the bulb and glass dome *b*, providing a complete spring support and preventing breakage even with the most severe shocks. Electric connection is established for one pole through the socket spring *o*, and for the other pole by another smaller spring *d* inside the socket spring, and insulated from it. In case the bulb breaks, the socket spring pushes the socket upward, and as the inner spring does not expand as much as the socket spring, the circuit is interrupted.

Lately, another safety device has been added, but is not shown in this illustration. It consists of a fuse, which blows the moment the bulb of the incandescent lamp is broken. This eliminates the possibility of obtaining sparks or getting the filament to glow in case the miner should attempt to push the bulb back into its normal position; it also protects the battery from being short-circuited for any length of time, in case the leads to the bulb have become short-circuited during the accident.

As stated before, the upper part of the lamp turns on the lower part, opening and closing the switch. This rotating movement is limited by a soft iron pin *m*, which acts as a magnetic lock. This pin can be withdrawn in the charging room by a strong electromagnet, and when this is done the upper and lower parts of the housing separate, and the battery can be removed for charging.

The storage battery consists of a single *round* lead cell with concentric electrodes inside of a celluloid vessel *A* covered with a waterproof lid of the same material. Cylindrical electrodes were given the preference over flat ones, as they are stronger and therefore stand rougher handling. They also warp less, so that in charging the current density can be increased and the length of time correspondingly decreased. The holes in the terminal sockets contain bushings made of acid-proof metal, into which removable terminals, p_1 and p_2, are fitted. These terminals are pressed upward by the terminal springs W_1 and W_2 against the contact segments K_1 and K_2 of the switch, carrying in this manner the current to the incandescent lamp. Terminals and springs can easily be taken out and cleaned by washing in warm water, a very important point. The use of non-removable springs has been found impractical, as they are very difficult to clean, consequently are liable to corrode and break easily. First-class contact springs, however, are imperative for an uninterrupted light service.

In charging storage batteries gases develop, which must have an opportunity to escape. It is therefore impossible to make the cells airtight. An ordinary opening, on the other hand, would have the disadvantage that the acid would run out in case a cell were upset, and this would destroy the housing of the lamp. In order to overcome this difficulty, the center of the cell is equipped with a celluloid tubing *B*, which is in communication with the upper part of the cell, where all gases collect, by means of a small side tubing *F*. The gases therefore can pass from the cell through the side tubing *F* and finally through center tubing *C* into the open, whereas any particles of acid carried along by the gases will deposit in cylinder *B*. Even if the cell is turned upside down, no acid which may be in cylinder *B*, or any other acid, can escape. In other words, the lamp will burn in any position without the acid being able to leak out.

The principal dimensions of this lamp are as follows: The weight of the lamp complete is about 5 pounds (2¼ kilogrammes); its height, not including hanger, is 10⅛ inches (26 centimeters); its largest diameter is 3¾ inches (9.5 centimeters). The incandescent lamp consumes 0.85 ampere at 2 volts. The battery has a capacity of 16 ampere-hours, and the maximum charging current should not exceed 2 amperes.

To meet various requirements this standard design is not only made in four different sizes, ranging in weight from 1½ to 5 pounds (¾ to 2¼ kilogrammes), but it is also made with two storage battery cells connected in series, resulting for the entire line in capacities ranging from four to sixteen hours of life for one discharge and producing light from 0.75 to 3 candle-power.

Besides this, a number of other modifications have been developed, so that mines can be completely equipped to-day with electric safety lamps, wherever a permanent wiring in connection with the lighting plant is impossible. Lamps are made for rescue parties, cages, powder magazines, shaft lighting, shaft inspection, loading places, blasting cars and locomotives (head and tail lamps), etc. A few of these modifications are shown in the illustrations.

The standard lamp, being of the "lighthouse" type, distributes its light uniformly over the entire surroundings. The modification shown in Fig. 3, known as the "trip" lamp, has the incandescent lamp mounted on one side combined with a reflector concentrating the light rays in one direction. This design is mostly used for inspection trips, and head and tail lamps for cars and locomotives. It is made in the same capacities as the standard lamp.

The "shaft" lamp illustrated in Fig. 4 is arranged with an adjustable arm, on which the incandescent lamp is mounted, so that the light can be sent in any desired direction. It is made for from 8 to 24 candle-power and from 7 to 12 hours of life for one charge.

Fig. 5 represents another type of "shaft" lamp, without an adjustable arm. It is made for 8 and 12 candle-power and for 15 and 10 hours of life for one charge.

The lamp illustrated in Fig. 6 is especially suitable for places in which ordinary illumination is not sufficient. It is made for 8 to 32 candle-power and for a life of 7 to 15 hours for one charge.

The lamps so far described were designed to take the place of the Davy safety lamp, which is in use in gaseous mines all over the world. In this country, however, the designer of electric safety lamps is confronted with another problem besides. In a great many mines the crews have and still use "naked" lamps fastened to their caps. On account of the strict enforcement of the mining regulations in recent years, a great many of these mines have been and will be compelled to substitute safety lamps. It is only logical that the men in these mines clamor for a type of electric lamp which is as near identical as possible with the present form of naked lamp. To meet this demand, electric cap lamps have been developed, the batteries of which are carried by the miner on his belt and are connected to the lamp by a well-protected special flexible cord. This lamp is shown in Fig. 7.

The principles of construction of the cap lamp (see Fig. 9) are identical with those of the hand lamp, besides several new features which have been added. One is that the incandescent lamp is mounted inside a parabolic reflector, the opening of which is closed by a lens, instead of being covered with a glass dome; another is a ball joint, permitting the miner to direct the light rays wherever they are needed. The third feature is embodied in the flexible conductors connecting battery and lamp. In case of an accident there is a possibility that the two conductors may become short-circuited and therefore red hot, eventually setting the insulation afire if they are made of copper or similar material. To prevent this a special alloy has been prepared, the melting point of which is considerably below the temperature which is required to ignite insulation or mine gas. Consequently, if a short circuit should take place the conductors would melt and interrupt the circuit before there could be a possibility of danger.

From the foregoing description it can be seen that portable self-contained electric mine lamps of this type have passed the first state of development, and if one considers that more than one hundred thousand are in daily use in Europe, apparently producing excellent results, there is no reason why the adoption of electric mine lamps in this country should not make rapid progress in the immediate future. The question whether hand lamps or cap lamps, or both, should be used, is a mere matter of detail which will adjust itself. European practice has adopted the hand lamp exclusively; the sentiment in this country, however, seems to be in favor of the cap lamp. Men who continually change their location in performing their duties will prefer the cap lamp, leaving both hands free for action; men who stay at work in the same place most of the time will favor the hand lamp, which can be set aside or hung up in the neighborhood, relieving them from carrying unnecessary weight.

LAMP SERVICE.

When the crew leaves the mine the lamps have to be delivered to the lamp room for recharging and cleaning. For this purpose the magnetic lock has to be opened so that the battery can be removed from the housing and placed on the charging rack. The unlocking is accomplished by pushing the lamp lock against the pole pieces of an electromagnet (shown in Fig. 10), which lifts the soft iron pin holding the upper and lower parts of the housing together.

Special charging racks have been designed to receive the batteries. The rack shown in Fig. 11 is intended for 80 cells connected in two series of 40 each. Each circuit is equipped with a switch ammeter and rheostat, so that the operator can determine the status of the charge at any time. The rheostats are provided with a surplus of resistance, so that less than 40 cells in a series can be charged if necessary. A portable voltmeter with a capacity of about 3 volts is provided to take the voltage readings on the individual cells. Cells are charged, ready for service, when their voltage reaches a value of 2.6. When more than 80 cells are to be charged, two, three or more racks can be combined, and all the cells can be charged at one time.

After the batteries are charged and the contacts and housings have been carefully cleaned, the lamps are reassembled and hung up on special racks from which the miners remove the lamps when they begin a new shift.

For mines using a large number of lamps it is essential that charging, cleaning and repairing be handled systematically and with proper care. For this reason special lamp houses are being erected on the same general principles as those for the Davy safety lamps, but simpler and cheaper, because it is not necessary to make special provision for the safe storage of the fuel like benzine. The ground plan shown in Fig. 10 represents a lamp house erected for 4,000 lamps. It consists of a building about 128 by 33 feet (39 by 10 meters) containing a charging room with twenty racks, six opening magnets, three small motors for buffing and cleaning and a small distribution board with a watt-hour meter. To the left of the charging room is the storeroom for receiving the lamps when they are ready for service, and to the right is a small shop for making repairs. Besides this a small room has been provided for a number of benzine lamps which are being carried for the fire bosses, and on another floor a washroom for the crew.

Proper care of the lamps has considerable effect on the reliability of the service. One of the large German mines, having several thousand electric lamps in daily use, reports that at first about 5 per cent of all lamps taken into the mine with the beginning of the shift were returned at the end of the same shift, either burning poorly or not at all. By a careful study of all details in the lamp house and by putting a skilled man in charge of the lamp house work, this percentage has been reduced to less than 1.5, with the expectation that it will soon drop below 1 per cent. That this last-named figure is not an exception is verified by the Bulleroft Main Colliery Company, Ltd., Doncaster, England. This company has more than 10,000 lamps in daily use, and reports the number of defective lamps per shift to be less than 1 per cent.

The investigation of these defects, if they amount to 1.5 per cent, shows the following:

Defects caused by the incandescent lamps.		
Lamps, burning dark	0.6 per cent	
Lamps with broken filaments	0.2 " "	
Lamps with broken bulbs	0.2 " "	
Total incandescent lamp defects		1.0 per cent
Defects caused by the batteries.		
Batteries, leaking	0.1 per cent	
Batteries discharged ahead of time	0.3 " "	
Total battery defects		0.4 " "
Defects due to other causes		0.1 " "
Total number of defective lamps		1.5 per cent

Records covering cost of installing and operating electric mine lamps in this country are not available to any extent because the number of lamps installed so far is not very large, and the time during which they have been in operation is comparatively short. However, it should be possible to form some idea of what can be expected from the experience in Europe.

Although the first cost of electric lamps is undoubtedly higher than that of benzine lamps, the cost of operation, including maintenance, is claimed to average from 10 to 15 per cent less for electric lamps than for benzine lamps. Whether the same results can be obtained in this country the future will have to decide. It may be added that the cost of the electrical energy is very small and that the cost of maintenance consists about one third of labor and two thirds of renewal of parts and depreciation.

Especially of importance is the cost of renewing the electrodes of the storage batteries, replacement of complete lamps, which are broken on account of rough handling and accidents, and renewing the incandescent lamps.

The life of the electrodes for lead cells ranges from about 100 to 400 shifts, depending entirely upon the treatment which they receive. At the present time large claims are being made for the alkaline cell, which is supposed to last as long as 2,000 shifts. This, however, requires verification by actual tests. Besides this, it must be borne in mind that the higher cost of the alkaline cell, the necessity of using two cells, in series, instead of only one as in the lead battery, and the increase in the renewal of the incandescent lamps, due to the large variation in the voltage, will fully wipe out this apparent advantage. However, the weightiest argument against this claim is the fact that the physical life of mining lamps cannot reach 2,000 shifts, as shown

below, and that the natural deterioration of all parts is considerably below this limit.

The replacement of complete lamps which are broken on account of rough handling and accidents undoubtedly varies more or less in accordance with the character of the work performed in the mine. European practice shows that about 0.1 per cent of all lamps per shift are lost in this manner.

The incandescent lamp renewal already has been expressed in figures in connection with the reliability of service. Excellent results have been obtained, the average life of the lamps being approximately 1,000 hours.

From the lamp designs and the lamp service as described above it can be seen that the development of the portable electric mine lamp has made rapid progress during the last few years, and since, up to this writing, no explosions have occurred wherever installations have been made, it can be said without exaggeration that the electric mine lamp is a success and that it is bound to be adopted more and more.

Of course, as is the case with any new appliance, objections have been raised against the electric mine lamp, especially because it does not detect inflammable gases as the Davy safety lamp does. There is no doubt that this detail will be overcome in the near future, as there are several principles which can be used for the construction of mine gas detectors. In fact, the German government only lately has ordered several hundred of these devices constructed in accordance with the directions of Dr. F. Haber on the acoustic principle and known as "mine gas whistles." These will be distributed to the various mines for a thorough trial.

British Aeroplane Building

THE building of aeroplanes is a new industry which does not need to be localized either with respect to the supply of raw materials or the economical distribution of the finished product. The product, in one sense, distributes itself; in practice, the finished aeroplane is crated and dispatched by rail, the freight charges being microscopical in relation to total value. The governing factors in selecting a site for an aeroplane factory are cheap land and the availability of skilled workmen. In the case of the Sopwith Aviation Company, Limited, an important factor was the existence of a body of expert wood-workers released by a decline in the Thames boat-building industry. Mr. T. Sopwith had been experimenting at Brooklands and made a successful biplane of the Howard-Wright type. He also made two tractors, i. e., biplanes with the propeller in front, and these were the forerunners of his present type. In January, 1913, he took over a disused roller-skating rink at Kingston-on-Thames and completed there a three-seater 80 horse-power tractor which had been started at Brooklands. His machines became known for soundness of detail and workmanship. One of his flying boats was first in the Mortimer-Singer competition for British-built aeroplanes, the test being to start on land, alight on water, restart, and repeat the performance six times. A demand for his machines sprang up, and soon Mr. Sopwith had government contracts. He started a year ago, at Kingston, with six men and a single bench; to-day the company, of which he is chairman, employs 70 men, and is building a new factory a short distance away.

The layout of the existing skating-rink shop, which will be retained, is, naturally, not scientific. The new premises, with a frontage of 150 feet and a depth of 120 feet, have been designed, under the direction of Mr. R. O. Cary, general manager of the company, especially for the purposes of aeroplane construction. There is a large central space provided for erecting; ample overhead lighting from a steel span roof, and wooden flooring on a concrete base. Along the frontage are stores and a garage. Along the back is a fireproof fabric room equipped with Singer sewing machines and with ample facilities for attaching the fabric to the wings. Above will be a fitters' shop running the whole length of the building, equipped with metal-working machines electrically driven. The front gallery will contain administration and drawing offices with northerly window lighting.

On account of the company being largely engaged upon Admiralty and War Office contracts, the shop comes under the Official Secrets Act, and, naturally all details of the government work are zealously safeguarded. Other than government work, however, is constantly in hand, and the following description of methods applies solely to matters in which secrecy is not imperative.

An aeroplane takes about two months to build. Its reliability depends upon the employment of skilled handicraft at nearly every stage. Except for obvious purposes, machinery is not employed. Moreover, aeroplane designs cannot be, or, rather, have not been standardized. Hence prices are high and wages above the local average. Each machine is built to order in the manner of a sailing yacht, with the construction of which many of the workmen are familiar. Details are being continually improved. There is no shop tradition. On the other hand, there is an almost extravagant amount of supervision.

The discipline of the drawing office is particularly strict, and under no circumstances are visitors allowed. Here draughtsmen not only design aircraft, but experts are continually studying the strength of materials. An aeroplane designer knows almost to an ounce how much stress or strain each part of a flying machine will have to bear. Every superfluous part of wood or metal is eliminated. The study of stream-lines, head resistance, and surface friction has been carried to a very fine point, and each part exposed to such action is shaped by hand for its purpose.

A flying machine consists essentially of three parts: the wings, the motive power, and the accommodation for the pilot. To these, in the case of hydroplanes, must be added the floats. The wings of a Sopwith aeroplane are built up with a trailing edge of steel tubing and two main longitudinal spars of ash. Curved struts of selected spruce and poplar run from front to back, a few inches apart. Steel clips, from which useless metal has been punched out, hold the woodwork of the wing together, and the whole is strengthened by a carefully calculated system of steel wire bracing. Although the whole wing will be afterward covered, every bit of woodwork is finished as though it were to be permanently visible. By this means any chance defect which might cost the life of the aviator is detected and remedied. To cut away the superfluous portions of the struts and spars, an interesting machine is in use. This comprises a blade attached to a vertical spindle. Immediately over the blade is an oval steel gage. The wood is placed under the gage and moved by hand while the knife cuts an aperture of the same shape as the gage. The wings are finally covered with a linen fabric which is at once strong, of light weight, smooth, unshrinkable, rot-proof, and in some cases fireproof. The fabric is of light khaki color, finished with five coats of "dope."

The construction of the floats for hydroplanes presents more technical difficulties than the building of a 'varisity boat race "shell." The bigger floats have a transverse step across the bottom, for the purpose of breaking the water-skin and allowing the planes to rise more easily. The step also throws the center of buoyancy to the stern and helps to elevate the leading edges of the wings. Most of the floats are completely decked, but in the case of the newer single float hydroplanes there is a well for the pilot. The bottoms of the floats are of three-ply cedar, and the sides of two-ply. This is all made on the premises. The designing of the floats is an art in itself and, for the most part, has been due to Mr. Sidney F. Burgoine, son of the Thames yacht builder. The floats are varnished with five coats, and all exposed woodwork of an aeroplane is also varnished. At the suggestion of His Majesty King George V, hydroplanes are now fitted with a movable plug, to save time in baling out water.

The Sopwith aeroplanes are fitted with various types of engines imported from France; the propeller blades are also made elsewhere, but with these exceptions, every portion of the aeroplane is made on the premises. There is a department for making gasoline tanks, which are designed to fit some peculiar but convenient position.

Aeroplanes are classified according to horse-power and seating capacity. The types usually made at Kingston are scouts, two-seaters, and hydroplanes with one, two, or three floats. The scouts usually have 80 horse-power engines, tractor propeller, and weigh 725 pounds unloaded. They cost about $6,500. Some new dual-control school machines built for the Greek government have the steering gear in duplicate, so that either the pilot or the passenger (generally a pupil) can operate it. They have engines of 100 horse-power, weighing, when fully loaded, 2,240 pounds, and cost about $8,750. A three-seater land machine is equipped with an 80 horse-power engine and costs $7,500.

The tendency in aeroplane design is to secure increased speed combined with capacity for landing and rising in a limited area. This involves the necessity of control at a relatively slow speed, apart from whatever high speed may be developed in action. The test usually specified for a scout aeroplane is to operate satisfactorily at speeds ranging from 40 to 90 miles an hour and to rise at the rate of 1,000 feet per minute. Such machines can be safely started and landed in a small field.

Microscopical and Colloidal Examinations of Jams*

The Difficulty of Detecting Adulterations

By Ernest Marriage, F.R.P.S.

THE analysis of these important foodstuffs to-day is not equal to the power in the hands of adulterators. Careful adulteration of a jam with a cheaper fruit jelly means a certain outlay in plant but an expenditure of money in this direction enables manufacturers to adulterate, or, as they say, "improve," their jams and to defy analysts. Anyone who takes the trouble to record cases of prosecutions will see that the caught culprits are, as a rule, small firms; the larger and well-known makers, though often equally blameworthy, escape detection.

Chemical analysis is of little or no assistance in detecting the blending of two or more fruits in jam. Fruit acids are very nearly related, and impossible to isolate, while they occur in varying proportions in most fruits. Malic acid is not confined to apples, nor citric to lemons, and so on. Possibly it might be worth while to examine jams for oxalic acid, as an indication of rhubarb adulteration. The iodine test for starch is useful if an apple adulterant, which has not been thoroughly filtered, is employed, as many apple cells contain starch; but even a home-filtered apple jelly may fail to show the marked blue reaction. Fig. 1 shows a section of apple stained with iodine; the numerous dark spots are starch grains. In the boiling to which the fruit is subjected the starch is broken up and diffused throughout the cell, but the cell walls are not broken, and the contents of the cell show the characteristic color. Fig. 3 is a specimen of "improved" raspberry jam in which the iodine test reveals the nature of the adulterant. Note the cells of apple containing starch, which are black in the figure. Gooseberries, another common diluent of the more costly jams, are free from starch, so iodine is no use in that connection.

Another chemical test consists in the introduction of alcohol into a solution of jam whereby the pectin is thrown out. The comparative absence of pectin is characteristic of strawberries, and affords some criterion of the purity of strawberry jam; it is the alleged pretext for adulterating this preserve with gooseberry or apple jelly. Yet other fruits, rich in pectin, black currants, for example, are treated with an admixture of apple. Looking deeper for the common cause of both these sophistications, we find that apples or gooseberries are cheaper for the jam-maker to use than strawberries or black currants.

Useful quantitative records of adulteration of jams with apple pulp can sometimes be obtained by the iodine test and photography without the aid of a microscope; but as the amount of starch present in apples is variable, depending on the maturity or ripeness of the fruit—probably upon the variety as well—the results obtained are now and then disappointing. In any case the darkened cells are only a proportion of the whole, and must not be taken to represent the total adulteration. A lens of short focal length, say two inches, and a camera with a long extension are necessary. The sample to be tested is made up in the form of a microscope slide, and an enlarged negative, preferably of the whole of the preparation, is taken in the camera. With an enlargement of ten diameters the

* Reproduced from *Knowledge*.

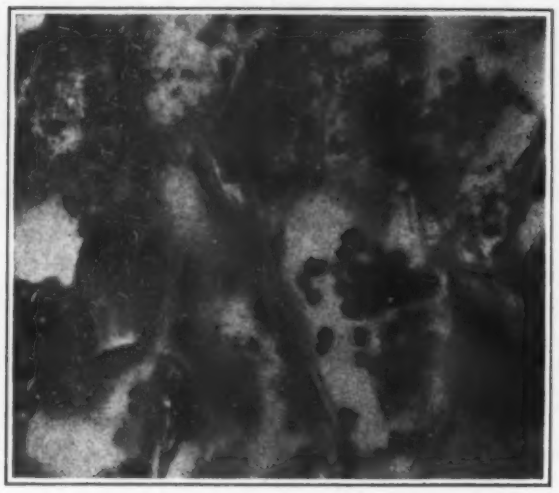


Fig. 1.—Section of apple, showing starch grains; stained with iodine. × 200.

Fig. 2.—Pure raspberry jam, lead iodide reaction on a slide. × 200.

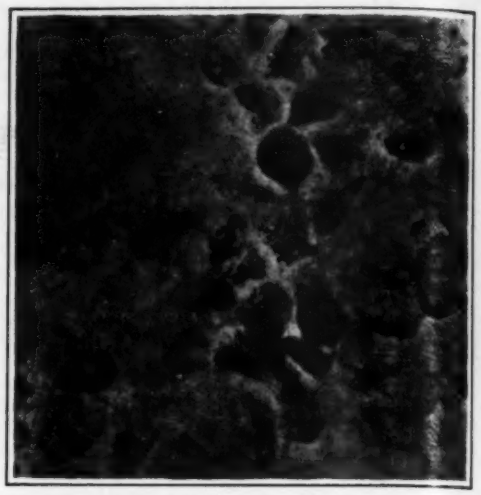


Fig. 3.—"Improved" raspberry jam, containing apple cells; stained with iodine. × 75.

darkened apple cells can readily be seen and their number counted. To prepare the slide, a drop of jam, free from pips, is placed on a microslip and mixed with a trace of iodine solution; a ¾-inch circular cover-glass is placed over the jam and pressed down with a cork ⅝-inch in diameter, until the layer imprisoned is as thin as possible. The slide is then ready for the photographer. An isochromatic plate should be used, with a yellow screen, to cut out the blue rays. Records obtained in this way of a pure raspberry jam and one "improved" with apple are shown in Fig. 7. The left semi-circle is the pure jam, while the dark oval specks in the other show the presence and frequency of the adulterants in the second sample. Micro-slides made in the above way are, of course, equally available for photomicrography, and the colorization of the apple cells makes them much easier to record (as we have seen above) than in their almost transparent, unstained condition; but the limited area included in a photomicrograph is insufficient to give even an approximate idea of the extent, though it affords positive proof of the existence of the adulteration.

Failing satisfactory chemical tests, the microscope offers a quick and ready method of picking out fruit adulterants, subject to the proviso that perfect filtration has not been employed. Microscopical examination of all foodstuffs is a highly important branch of analytical work. For investigating jams a high magnification is not required; the enlargement of fifty to one hundred diameters is generally sufficient. In making photomicrographic records it is well to keep one standard magnification; by so doing there is less danger of confusion. The cells of apple are smaller than those of gooseberry or plum, but at a higher magnification might easily be mistaken for either of the latter less magnified.

When recourse is had to the microscope, three or four methods of examination are available, viz., by transmitted light, dark ground illumination, opaque illumination, and polarized light. Of these, without doubt, the polariscope is the best optical means of showing the fruit structure and cells in an unstained slide. I have dealt with the value of the iodine test for apple; the polariscope is especially useful in the detection of gooseberry. Gooseberry cells are large, but the main characteristic of the fruit is that a fair proportion—not all—of the cells show bright minute specks when the nicols of the polariscope are crossed. Fig. 5 shows gooseberry cells in an "improved" strawberry jam. I do not know the nature of these specks; they are not crystals, the raphides of the microscopist.

There is no great need to dwell upon the special characteristics of more costly fruit, as in spite of the fact that jam-makers claim on their labels to improve their wares, they invariably do so with cheaper fruit. Minute hairs from the skin of the fruit are very apparent in raspberry (see the minute tubes in Fig. 3) and loganberry jams, but are occasional only in blackberry or strawberry, and absent from apples, currants (red and black), gooseberries, and plums.

Familiarity with the appearance of pure jams is, of course, essential, and for this experience it is best to rely entirely on jams made at home. The number of manufacturers who make pure jams is small, and they are being forced out of the trade by fraudulent competition. Sections of the actual fruit, too, should be examined. These are not easy to prepare. Thin sections can be obtained by infiltration with paraffin or celloidin, but I think that the results so obtained are misleading, and that sections of the fresh fruit, say one hundredth of an inch (or more) thick, soaked in dilute formaldehyde and then mounted in glycerin jelly, are more suitable.

Though the use of the polariscope is of prime importance, the ordinary examination by transmitted light must in no wise be neglected. Dark-ground illumination, unless the polariscope is not available, is of minor importance. Opaque illumination by the Lieberkuhn, though useless for jams, is valuable for dealing with pips, or examining the surface of fruits or vegetables in their natural state. I shall have occasion again to refer to the Lieberkuhn below.

The examination of jams for incriminating fruit details is useful up to a certain point, but when the adulterant has been carefully filtered, the microscopist may make his bow and gracefully retire from the contest with the adulterator, as the chemist has practically done at the outset. We have seen already, with the iodine test, that a combination of chemistry and microscopy has advantages over the individual sciences. In that case we were dealing with unfiltered jams; may not the same hold good with filtered jellies?

In February, 1911, Emil Hatschek read a paper, "A Study of some Reactions in Gels," before the Society of Chemical Industry (see the *Journal of the S.C.I.*, March 15th, 1911, No. 5, Vol. XXX), in which he showed that precipitates of certain insoluble salts in various gels differed, not only from precipitates obtained in corresponding aqueous solutions, but also among themselves. He suggested to me that a study of the precipitates formed in fruit jellies might give a clue to their origin, and so enable adulteration to be detected. As the lead iodide reaction gives very different results in gelatine and agar-agar, it seemed to offer the best chance of success, and though I have experimented a little in other directions, my investigations have been practically limited to this one reaction.

It is essential that the jelly tested be thoroughly filtered, so the precautions taken by the jam-faker to avoid detection are helpful rather than otherwise for our present purpose. Any fibers or vegetable *débris* in the jam affect the regular deposition of the precipitates. A convenient amount of jam for a test is 30 grammes, which should be dissolved in about 300 cubic centimeters of hot distilled water. Dissolution is best performed in a flask in which the mixture can be boiled. The solution should be filtered while hot, by means of a suction filter, and the bright solution of jelly concentrated by heating until a standard boiling-point is reached: 225 deg. Fahr. is convenient. The weight of jelly is now taken, and enough potassium iodide is added thereto to make a 5 per cent solution of the salt. In practice it is more convenient to add the potassium iodide in the form of a 20 per cent solution, rather than try to dissolve the crystals in the jelly direct. Assuming that a solution is used, the correct proportion is mixed in with the jelly, which is reboiled to the standard temperature and then poured out into test tubes. Two inches of jelly in each tube will suffice.

Having reached this stage, it is better to defer the next operation—the introduction to the tubes of a 20 per cent solution of lead nitrate—until the following

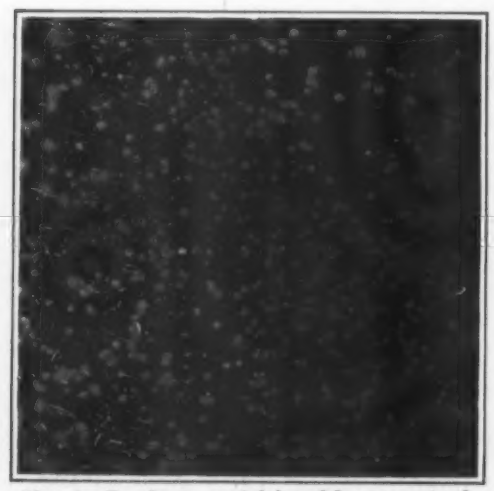
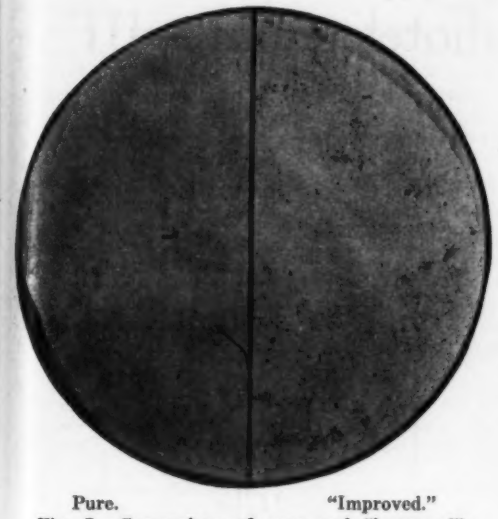


Fig. 4.—Raspberry containing 0.2 per cent of agar-agar, lead iodide reaction on a slide. × 200.

Fig. 5.—"Improved" strawberry jam, showing gooseberry cells. Seen by polarized light. × 75.

Fig. 6.—Raspberry containing apple, lead iodide reaction on a slide. × 200.



Pure. "Improved."

Fig. 7.—Comparison of pure and "improved" raspberry Jams. Iodine test. × 4¼.

day, in order that the jelly may set thoroughly. In the case of strawberry a delay of several days is desirable, in order to give the surface time to harden a little, otherwise the skin of the jelly will be broken, and the lead nitrate solution mechanically mixed, instead of diffused, in the upper part of the jelly. Another way of dealing with a tender jelly is to cover it with a thin layer of a stronger jelly. I have successfully used glycerin jelly for this purpose. This plan should only be regarded as a *pis aller;* the introduction into the test of a foreign colloid must be considered undesirable.

A few tests made in this way are shown in Fig. 8. Reading from left to right, they are apple, apple and gooseberry (equal parts), gooseberry, loganberry, and raspberry jellies. Apple jelly shows little or no tendency to yield the layers of lead iodide precipitates, which are a common feature in this branch of research. Layers are numerous in gooseberry, and, as might be expected, this formation can be traced in the apple and gooseberry mixture. Stratification is visible in loganberry, while in raspberry it is strongly marked, and the interspaces are unusually clear. Visual examination of the test tubes is secondary in importance to a microscopical examination of the deposits.

The largest aggregates are found low down in the tube in the interspaces, the layers being composed of small bodies closely packed. To obtain the large aggregates undamaged, I break the tube; suitable portions are then taken with a knife, and mounted in a thin tin cell, using the jelly as a medium. The cell is fastened to the slip with marine glue, and a coating of the same cement is applied to the upper surface of the cell; a drop of the jelly containing the aggregates is placed in the cell, and the cover-glass on top of it. The slip is then held, face downward, over a spirit lamp until the moisture, which condenses on the glass in a cloud, has just cleared, when the slide is sealed by pressing it, face down, against a piece of tissue paper placed on a flat surface, such as a sheet of glass.

For the microscopical examination of these slides, I find nothing better than a 1-inch objective and a Lieberkuhn. The aggregates are too opaque to be viewed by transmitted light, only their outlines being apparent, but dark-ground illumination is quite feasible. Aggregates of lead iodide formed in fruit jellies are shown in Figs. 10-12. The specimens were obtained from the first three tubes in Fig. 8. Apple shows rounded groups of smaller spheres. In gooseberry the groups are more irregular, generally three or four-lobed, and seem to be built up of flat disks. In apple and goose berry the nodules are intermediate, but I cannot claim that they have marked characteristics; they seem, perhaps, more to favor the apple type.

In colloid bodies, such as gelatine, agar-agar or starch gels, the lead iodide reaction in test tubes is not long in reaching the stage when the results can be usefully examined—a week will generally suffice—but the addition or presence of sugar inconveniently delays matters. A fruit jelly may take six or eight weeks before it is ripe for examination. It occurred to me that by carrying out the tests in microscope slides a complete record of all stages of the reaction might be obtained in a convenient shape. Upon experimenting in this direction it was found that this plan gave results in a few hours, instead of days or weeks, though I am afraid that the aggregates in the confined space of a microscope slide cannot assume such characteristic forms as those grown without restriction.

The jelly to be tested is prepared in the same way as for tube tests. I generally employ the small surplus left after filling the test tubes for making three or four

A B C D E

Fig. 8.—Lead iodide reaction in filtered jams. (A) apple, (B) apple and gooseberry, (C) gooseberry, (D) logan, and (E) raspberry.

slides. A drop of the jelly is placed on the center of a clean slip, and a thin ¾-inch cover-glass is placed upon the jelly. The slip is next held over a spirit lamp until the jelly begins to boil. The slip is then placed on the table, and the cover-glass pressed down with a ⅝-inch cork, and held until all bubbling has ceased, and the slide has cooled. The preparatfon should now be transparent and free from bubbles, and with a surplus ring of jelly round the outside of the cover-glass. After a 15 or 30 minutes' rest, the slide is placed in a bath of 10 per cent lead nitrate. The surplus unprotected jelly turns yellow at once, and gradually the formation of lead iodide proceeds inward under the cover-glass. If all goes well, the action proceeds with perfect regularity, and may be stopped in about eighteen hours. It is undesirable to leave a slide in the bath too long, as it is more difficult to seal up afterward. There should be a circular area in the middle of the slide, of about one eighth of an inch in diameter, free from the yellow deposit. Fig. 9 is a particularly fine example. Sometimes irregular action takes place (in tubes as well as

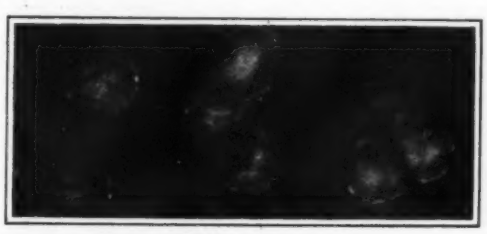


Fig. 10.—Apple.

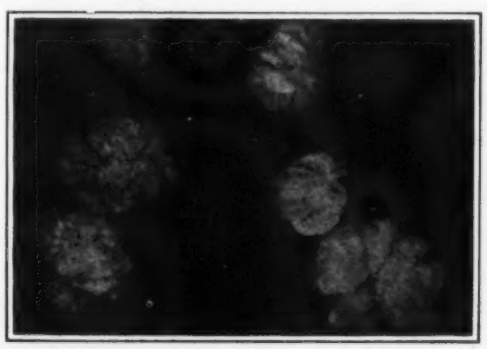


Fig. 11.—Gooseberry with apple.

Fig. 12.—Gooseberry. Lead iodide aggregates from test tubes. × 100.

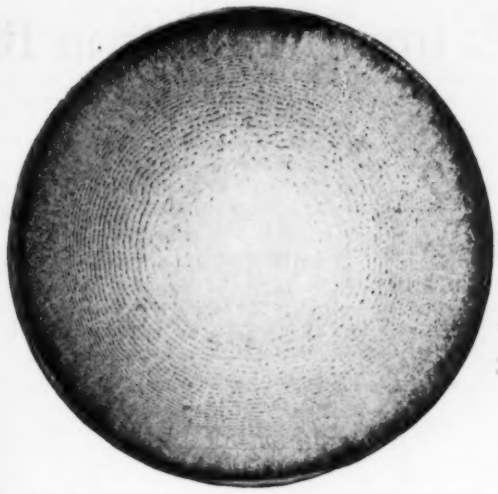


Fig. 9.—Raspberry jam, lead iodide reaction on a slide. × 4¼.

slides); instead of concentric markings, we get opaque masses and broken curves. Tender jellies, such as strawberry, are prone to give trouble in this way. Two preventive measures may be taken: enough jelly should be put on the slip at the outset to insure a surplus all round the cover-glass (too much is messy, but does no harm, too little is likely to cause trouble); or, secondly, the jelly may be taken to a higher temperature. A pure strawberry jam would require boiling to 230 degrees, while an "improved" jam, containing gooseberry or apple, gives no trouble at 225 degrees. The boiling-point of a jam containing agar-agar is lower still.

When the reaction in the slide has proceeded far enough, the slide is taken out of the bath, its surplus jelly carefully removed with a brush, rinsed in distilled water, and dried quickly. It is then promptly ringed with old gold size on a turntable, great care being taken to avoid touching the cover-glass with the brush, while the size must flow right up to and embrace the edge of the cover. When the size is dry another coat should be applied, this time going over the edge of the cover. A coat or two of enamel and a final application of gold size will make the mount firm enough to clean without damage to the preparation. Care must be used, as pressure on the cover-glass will break the larger aggregates, especially when they are spherical in form, as in the case of pure raspberry. A slide of raspberry jam prepared in this way is shown, slightly magnified, in Fig. 2. For making records of complete slides I use a 2-inch Aldis photomicrographic lens in the camera.

Here, as with test tubes, the larger particles are found in the interspaces. The aggregates in slides are, however, so thin that they may be examined in the microscope by transmitted light, or, in fact, any other method of illumination. The formations are minute, and require a higher magnification to record them. Our illustrations record the tests of raspberry jams, one pure and two adulterated. The first, Fig. 2, is a pure jam; the layers are strongly marked, and larger individual aggregates are rounded and opaque. Fig. 6 is a raspberry and apple jam (otherwise an "improved" raspberry jam), and 25 per cent of the fruit content is apple juice. The jam is so well prepared that the microscope alone does not reveal the adulterant. Here the layers consist of a cloud of minute particles, while the aggregates are translucent disks; only here and there can the opaque form be discovered. Lastly, in Fig. 4, we have a raspberry jam with a minute trace of agar-agar, 1 part in 500. The formation of layers, though discernible under the microscope, is barely noticeable in the small area reproduced, while the appearance of the aggregates is different from the other examples.

It is necessary to bring considerable experience to the interpretation of the tests outlined above; even then it is improbable that small percentages of adulterants could be detected and accurately determined without far more care and attention than I have been able to bestow upon these investigations. If, however, it is possible by this means to detect large admixtures of filtered jellies, an important advance in the analysis of jams has been made. It is confessedly impossible today to tell whether or not a red currant jelly is pure; if filtration has been thorough the microscope reveals nothing, and the analyst can only report that he finds no evidence of the introduction of other fruit. Colloidal investigations should indicate the presence of gooseberry or apple in most commercial jellies.

It is desirable that other reactions should receive careful attention; it is conceivable that a certain reaction may give particularly characteristic aggregates with one jelly, and so lead to its easy detection as an adulterant.

Improvements in Radiotelegraphy and Radiotelephony—III*

A Review of Some Recent Patents

By W. H. Eccles, D.Sc.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2005, Page 335, June 6, 1914

IN patent No. 28,070/1912, granted to La Compagnie Générale Radiotélégraphique, an ingenious system of connections for facilitating the tuning of a receiving set is explained. Fig. 21 illustrates the matter diagrammatically. Suppose, first, that the antenna and secondary are right out of tune with the signals to be received, and let the switch N be over against the point O. The telephone T and the detector L are in a non-oscillating circuit closely coupled to the antenna at RD, and, therefore, by varying either the antenna inductance at D or the antenna condenser at F, or both, the signals can be picked up. Then, while keeping the switch on O, vary the condenser C or the inductance S, or both, in the secondary circuit $SQCBE$, which is loosely coupled to the antenna at BE. As this circuit comes more nearly into tune with the signals, the loudness of the sounds in the telephone will diminish, till when the circuit is perfectly in tune there will be no trace of the signals. One way of explaining this is to observe that the energy picked by the antenna from a train of damped waves is passed in much greater proportion to a circuit in resonance than to one not so adjusted; but another explanation is offered in the specification at much greater length. Thus, when the signals have vanished from the circuit, including the point O, the switch may be moved over to P, and the signals be found in strength in the loosely-coupled secondary.

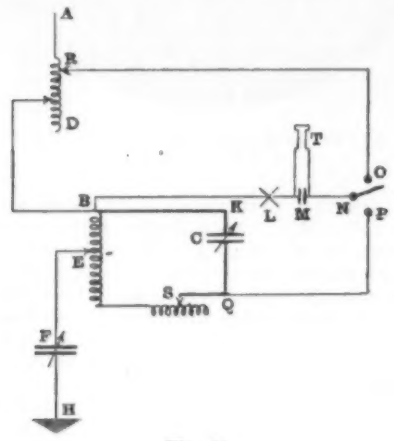


Fig. 21.

In specification No. 86/1912, G. Marconi and C. S. Franklin describe a theoretically simple means of enhancing the instability which is responsible for the operation of certain kinds of detector. The proposal is to include a series-wound dynamo in the detector-telephone circuit. Then if a train of oscillations causes in the usual way an increase of the current in the detector-telephone-dynamo circuit, the electro-motive force generated in the dynamo is raised and the instability of the detector increased. The consequent increase of current is limited, of course, by the current of the detector. It is stated that in effect energy is given by the dynamo to the circuit, and that the current may be used to work a relay and printer or sounder. As usual when using detectors at points of instability—e. g., the filings coherer—it is necessary to arrange that the circuit is broken after each signal in order to restore the detector to its original condition. An ironless dynamo is preferred, or if iron is used, it should be finely laminated and worked at low magnetic density.

A patent granted to the Marconi Company and H. J. Round, No. 3,055/1912, is concerned with the elimination of the effects of natural electric waves. It will be remembered that among former proposals a favorite one has been to use two antennæ, one tuned to the signals, the other slightly mistuned. An "X," it is stated in the specification, sets up equal oscillations in the two antennæ, and therefore if these two sets of oscillations are rectified by two suitable detectors, the currents may be passed oppositely into the telephone and annul each other. The new proposal set forth in this specification is to produce the cancellation at an earlier stage of the process, so that only one detector is needed. To do this the currents in the out-of-tune antenna are passed through the stator of an alternator, the rotor of which is so constructed and rotated as to make the frequency of the currents in it equal to that of the X-oscillations in the tuned antenna. The two X-frequencies being now the same, may be set in opposition in a third circuit, to which the detector is coupled. Various elaborations of the method are discussed.

In specification No. 8,821/1913, the Gesellschaft für drahtlose Telegraphie describe a method of using gas ionized by a glowing cathode for the purpose of strengthening oscillatory currents of any frequency. The valve action of the ionized gas is not utilized, and it is claimed that the wave form of the oscillating current is not affected by the strengthening. Fig. 22 shows the principle plainly. The antenna f collects the waves and excites the secondary coil g, and therefore the electromotive force of the battery h is alternately augmented and diminished. The current from the auxiliary anode a to the glowing cathode c across the gas is thus alternately large and small. This reacts on the gaseous current which is forced by the battery i across the gas between the anode a and the cathode c, and the amplitude of the pulsations of this current may be made greater than the amplitude of the original oscillations by making the electro-motive force of the battery i large enough. The magnified high-frequency oscillations in the circuit $idck$ are transformed by the transformer k, then rectified by the detector l and passed to the telephone m in the ordinary way. The pulses of unidirectional current sent ordinarily by the detector through the telephone may be magnified in a similar way before reaching the telephone, and both magnifications may be arranged to be performed by one and the same vacuous tube.

Among other specifications of interest in connection with receiving apparatus is No. 24,043/1912 of S. G. Brown, who gives very full details of certain improvements on his well-known single-point telephone relay. These details consist chiefly of improvements in the substances used at the contact—carbon now being introduced as one electrode—in the arrangement of the lever carrying the currents, and in the means provided for adjustment.

Another interesting specification is that of H. Merton, No. 11,714/1912, where a description will be found of an ingenious mechanism for starting and stopping a recording phonograph when a signal starts and finishes in the operator's absence. The inventor's first claim covers the combination of wireless telegraph receiving apparatus with a device for magnifying the signals, and with a phonograph for recording the magnified signals.

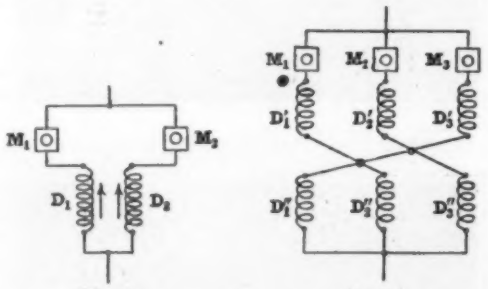


Fig. 23.

Fig. 24.

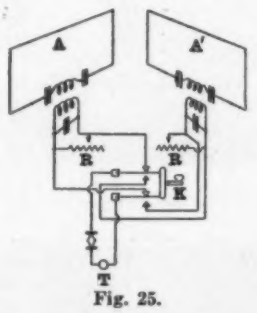


Fig. 25.

Fabio Majorana, in patent No. 10,154/1913, obtains protection for an improved telephone relay of a very simple kind. In one form of the invention the stretched wire of a string galvanometer carries one electrode of a microphone contact. The wire is situated in a strong perpendicular magnetic field, and deflects when a current passes along it. The consequent movement of one side of the microphone contact produces variations of current in a circuit which includes the contact. In another application of the invention the motion of the wire is arranged to produce a compression of the supply tube of a jet of conducting liquid. The compressions of the tube produce vibrations of the jet, which can be utilized for wireless telephony in the same way as the inventor has previously employed microphonic jets.

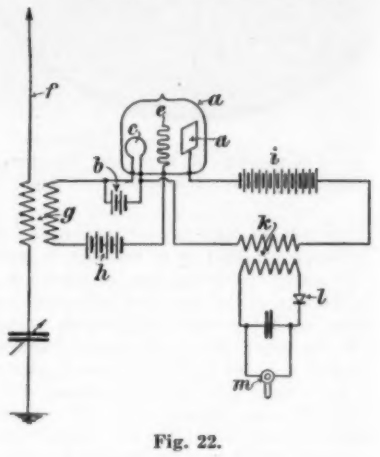


Fig. 22.

RADIOTELEPHONY.

There are very few inventions to chronicle in wireless telephony, if regard is paid only to those introducing some degree of novelty in principle.

In specification No. 15,915 an ingenious method of enabling microphones to be worked in parallel satisfactorily is described by R. Goldschmidt. As it is impossible to make two microphones which will remain perfectly alike electrically, it has hitherto been necessary to use microphones in series. The present invention overcomes the difficulty for a pair of microphones by putting in series with each microphone a coil so wound that the surging of the compensating currents, which always arise through unequal operation of the instruments, is prevented by the mutual inductive action of the coils. Fig. 23 shows the arrangement: M_1, M_2 are the microphones, and D_1, D_2 are coils wound oppositely on a common core. Equal currents down the coils cancel each other's magnetic field, but a circulating current would build up a field, and therefore experiences a great choking effect. When more than two microphones are to be connected in parallel they may be caused to work uniformly by pairing them and applying the above method. But a more advantageous arrangement is that shown in Fig. 24, where coils D_1' and D_1'' act on each other, and the remaining coils are paired similarly. Still another method is given in the specification. A coil in series with each microphone acts on one and the same secondary current. If the microphones operate unequally the presence of the secondary tends to choke the circulating current; if they operate equably the secondary current tends to neutralize the self-inductance of the coils. The method promises to be of importance in radiotelephony. It suggests, by the way, the possibility of making oscillatory arcs work in parallel.

MISCELLANEOUS.

F. J. Chambers's specification No. 7,242/1912, proposes the establishment of a system of signaling by electromagnetic waves of very low frequency as compared with those hitherto used, with frequencies in fact of acoustic order. The radiating and receiving antenna is to be an "earth antenna" similar in kind to that experimented with by Kiebitz in recent years. It is suggested that sufficient radiation will be detached, even at low frequencies, for the purposes of telegraphy, and this in spite of the fact that the line "radiators (shall be) laid horizontally in or at a short distance from the earth." If energy can be radiated in sufficient quantity the receiving station demands no more apparatus than a telephone receiver, and certain tuning devices, for its operation. The patent covers a great many developments which have been carried over from the practice of ordinary wireless telegraphy. The system proposed is very similar to that of Bouthillon, which has been tested in France on an antenna 60 miles long with wavelengths of the order 300 kilometers.

A method of determining the direction from which signals are coming to a receiving station is given in specifications by the Marconi Company and C. E.

* Reproduced from the *Electrician*.

Prince, Nos. 2,456 and 2,457/1912. In the former two tuned vertical rectangular antennæ fixed in planes at right angles have the intensity of the oscillations compared by a convenient method. The method emphasized is shown in Fig. 25. By adjusting the resistance R to obtain equality of sound with key K in the up and in the down position, the measurement is effected with fair accuracy. The second specification uses a directional antenna A and a non-directional one, A^1, and makes the comparison either in the same way, or by a variable coupling in the non-directional antenna A^1. The variable coupling may be calibrated to read the azimuth of the sending station direct. The principal distinction between this method and that of Bellini and Tosi is that in the present method the intensities of the oscillating currents in the antenna are compared, and in the Bellini and Tosi method they are combined and the maximum resultant sought for.

A suggestion for the removal of the chief defect of vertical closed circuit antennæ is found in patent No. 4,514/1913, granted to the Marconi Company and C. S. Franklin. The defect referred to is that the radiating and absorbing powers of such antennæ are small on account of the fact that portions of wire-carrying currents more or less opposed in phase and equally potent in radiating, are usually rather close together, and so neutralize one another at a distance. According to the present specification, condensers are to be introduced at "approximately equal distances all round the closed aerial circuit, the capacity of each condenser being so adjusted that for the particular wave-length to be used it just compensates for the inductance of the part of the circuit joining it to the next condenser." If the earth be used to form the lower side of the vertical rectangle, or polygon, the antenna becomes a loop-antenna. It is mentioned that for practical purposes the condensers may be placed in water-tight cases at the tops of masts, and should be shunted by coils of high inductance to prevent the accumulation of electrostatic charges.

Specification No. 15,674/1913, describes an invention of J. G. Balsillie, which makes much use of looped antennæ and of condenser coupling. A looped antenna, i. e., an antenna consisting of up and down vertical portions connected at the lower ends to earth and connected by a horizontal wire at the upper ends, has a variable inductance and a variable condenser in the idle leg, and a variable condenser only in the active leg. Tuning of the antenna is effected by aid of these variables. The condenser is shunted by a variable inductance coil and a variable condenser, and this variable inductance coil is the primary of a tunable circuit containing a detector and associated with a telephone. Put briefly, a tunable looped antenna is coupled by a condenser to a secondary tunable circuit, and this is coupled inductively to a detector-telephone combination. The specification points out that if both legs of a loop antenna are arranged like the active leg described above, but both having the same detector and telephone circuit, the apparatus is suitable for the reception of messages in which the dots are transmitted on one wave-length and the dashes on another. The specification also points out that the telephone circuit may be tuned to the note of the signals.

Protection of Battleships During Darkness

PERHAPS the most difficult of all the problems which present themselves in the general design of war vessels is that of constructing in imagination in times of peace the probable conditions which may have to be faced in times of war. Fortunately, for mankind, if possibly unfortunately for the designer, there is very little real information as to the exact conditions which may prove most onerous during hostilities. Even the enlightenment which resulted from the Russo-Japanese War has become to a large extent obsolete as a result of the developments which have taken place since. The increase in speed and size of destroyers has been matched, if not outmatched, by the increase in speed and gun range of the larger units, but against that must be put the untested possibilities which lie in the growth and development of the submarine. The issue as between opposing battle fleets during daylight on the high seas may be more or less actually forecasted. It was made evident in the Japan Sea that heavily armed battleships would generally fight their battles at a distance governed by the effective range of their heavy armaments, and it seems probable that in daylight conditions an attack by destroyers on a modern battleship would meet with resistance that would make the proceeding a rather hopeless experiment for the destroyers. Submarine attack, as it would be carried out with the latest type of submersible craft, is a more insidious and dangerous menace, even in daylight, for the huge bulk of a battleship makes her an easy target for the torpedo of modern design, with its improved range and precision. Under cover of darkness destroyers as attacking forces are much more dangerous, and this, added to the still greater risk of being torpedoed by a hostile submarine, makes the problem of security during hours of darkness a very serious one for ships of the line. It is being generally recognized that these vessels are then inadequately protected, for, while a daylight attack by destroyers and submarines might be beaten off by the 6 inch quick-firing equipment, or possibly by the use of shrapnel in the heavier armament, it is not so likely that these small vessels would be detected and stopped in time to prevent effective discharge of a torpedo under cover of partial or complete darkness. This weakness is the Achilles heel of the modern Colossus. For a long time it was considered that adequate protection against torpedo attack was provided by using a screen of torpedo netting, but it has been shown that these nets can be pierced by suitable cutters when the ship is at anchor, and that when she is under way, even at moderate speeds, the nets fail to keep in position, and so leave the ship open to successful attack. The unwieldy and cumbersome fitting has therefore been discarded, and the problem of adequate protection is one of considerable magnitude; it is a matter of great concern to many naval officers that such a powerful and costly creation as a modern battleship, protected against gun-fire by, perhaps, 6,000 tons of armor, and able to deal deadly blows with ten or more 15-inch guns, should be so helpless to resist torpedo attack at the soft ends, and below the armor belt, by vessels which may be able to approach without detection.

Obviously the first suggestion for dispelling a danger, which is primarily caused, or at least greatly increased, by darkness, is to provide artificial light, so that the surface of the sea may be swept continuously by beams from an arc light projector. Considerable attention has been given to this phase of the subject. A paper published in the *Journal* of the Royal United Service Institute by Captain Pinelli, of the Italian Navy, deals very exhaustively with the best methods of using searchlights for this purpose, and of making them both effective and reliable. He would, in the first place, have plenty of these lights, and divide them into two classes —one of them called "searching lights," and the other "gun lights." The searching lights, he considers, should be placed about 8 meters to 12 meters above the water-line; they should be at least eight in number, and placed at the center line on supports something like telescopic masts, capable of being lowered so that the projectors may be stowed behind armor protection in daylight, when they would be most subject to damage from gun-fire. "Gun lights," he thinks, should be situated about 30 meters to 35 meters above the water-line, and, while he would like to have many of them also, the necessities of the case limit the number which may be adopted; he would not in any case have less than four. The fitting of searchlights is, of course, universal; but the suggestion of Captain Pinelli to divide them into two groups having different functions, with operators trained to use them in a specific way, is worthy of consideration. The duty of the searching lights is to sweep completely, segmental sections of the horizon, so that a hostile vessel may be detected; this done, the duty of illuminating the enemy would be taken up by a gun light, simultaneously with the opening of gun-fire upon her; the searching light then resumes its previous duty of searching the section appointed to it. Such a scheme may be so developed that the whole neighborhood of a battleship is almost as effectively watched by night as by day, but there is, perhaps, no tactical question more warmly debated than that of the desirability or undesirability of using such a method of illumination at all. There is a very strong school of thought among naval officers which asserts uncompromisingly that the safety of a battleship from attack at night lies in maintenance of complete darkness in her vicinity, and that searchlights should be used for navigation purposes alone. It is just here that controversy occurs, for, while it is generally agreed that darkness is the best defense so long as the vessel is undiscovered, opinion is sharply divided as to whether or not searchlights should be used when she is so discovered. Those who advocate darkness say that the attacker has as much difficulty as the battleship in the dark, and that it cannot be contended that a destroyer may be dazzled by the beams of a searchlight, for with a pair of tinted glasses the commander can see all that is necessary to his purpose. On the other hand, it may not be possible for a battleship to remain in the dark, for, although her own lights be extinguished, the attacking vessels, or possibly one of them, may accept the risk of drawing gun-fire, and use her searchlights to discover the whereabouts of her foe. Evidently there is room, not only for keen discussion on this point, but also for inquiry and experiment. Our point just now is that there is considerable doubt in the minds of those most capable of judging as to the efficacy of artificial light as protection against torpedo attack. What, then, is the most effective means of safeguarding ships of the line from mosquito attack?

The answer to this is probably to be found in the new class of swift destroyer-destroyers, which is in process of construction for the British Navy. The first of these ships to be launched from a private contractor's yard is the "Undaunted," which was put into the water recently by the Fairfield Company. She is one of eight similar vessels ordered under the 1912-13 programme; they are 410 feet long, 39 feet broad, and have a displacement of 3,500 tons. Turbine machinery of 30,000 horse-power is disposed on four shafts, and the speed expected is not less than 30 knots. Steam is generated in Yarrow water-tube boilers fired with oil fuel; the armament consists of 6-inch quick-firing guns, which are generally acknowledged to be the most effective weapons for the destruction of destroyers. The vessels are lightly armored for a considerable portion of their length, the protection being 2 inches or 3 inches in thickness, sufficient to resist the attack of guns usually fitted to destroyers. These ships, which were described by the First Lord of the Admiralty as "the smallest, cheapest, and fastest vessels protected by vertical armor ever projected for the British Navy," are obviously, just the type demanded for adequate protection of a fleet of battleships; they can be eyes and ears to the main body, and are both strong enough and fast enough to overhaul and destroy the present class of destroyers, for their size will enable them to keep the sea and maintain a high rate of steaming when smaller vessels must necessarily reduce their speed. They are fitted with long and high forecastles, and are calculated to form a very efficient defensive screen for the operations of a battle fleet. Each of the four shafts has both an ahead and an astern turbine, so that their maneuvering qualities should be of a high order. The design is an attractive one, and satisfies a very obvious need. It is a case of prevention being better than cure, for if these vessels acting as scouts be used as a screen to the fleet they should be capable of preventing any attack by destroyers or even by submarines in force sufficient to be dangerous. We have advocated in these columns the creation of such a class, as clearly indicated by the needs of present day war conditions, and we think it probable that the new vessels will meet with general approval.—*The Engineer.*

The Varron of the Ox

A NEW and important communication has just been made to the Academy of Sciences by M. Edmond Perrier, Director of the Natural History Museum, in the name of M. Adrien Lucet, member of the Academy of Medicine, concerning the hypoderm fly or *varron* of the ox. The larvæ of these flies secrete under the skin of the back of the ox, where they increase in size and cause abscesses. The animals attacked in this way grow thin and the flesh is unserviceable, and their hides become pierced like a sieve. For these reasons agriculture and the leather industry lose enormous sums annually. In order to extract the larvæ the only means known up till now was to press the abscesses enclosing them with the hands, or else, after having opened the tumor, to take them out with the help of pincers. According to numerous experiments he has performed, M. Lucet affirms that it is possible to destroy this parasite in the bovine species in the sub-dermic tumors where they live by the aid of the injection into these tumors of a few drops of tincture of iodine.—*Chemical News.*

The Mineralogical Constitution of the Shetland Isles

M. E. GOURDON, geologist of the French Antarctic Expedition (the Charcot Mission), has studied the geological constitution of the Shetland Islands. Deception Isle affects the curious form of an almost perfect ring of land; the narrow passage by which the little inland sea communicates with the ocean measures barely 200 meters of navigable width. It is an immense crater invaded by the sea. In the island that is entirely volcanic, the glacier phenomenon is to be found side by side with the volcanic phenomenon; fumaroles of 90 degrees are to be found even in the midst of fields of snow; layers of ice alternate with the layers of ashes. The island is formed of yellow tufas, in the midst of which crop out oozings formed by trachytes, andesites and labradorites. Large blocks of basalt are also to be met with.—*Chemical News.*

Fig. 2.—Cutting a crankshaft on a double cold saw.

Some American and European Types of Electric Cold Saws

Recent Designs Illustrated

By Frank C. Perkins

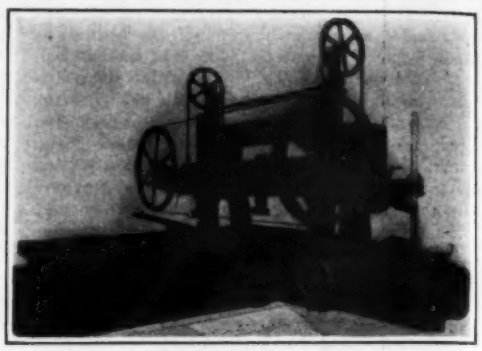


Fig. 3.—Horizontal band sawing machine. Scotch make.

THE accompanying illustration, Fig. 4, shows an American electric-driven cold saw cutting-off machine designed at Philadelphia, Pa., and is of special interest in considering the development of cold saws in this country as well as in Europe.

The machine carries two saw blades 36 inches in diameter mounted on an extension of the spindle 8 inches in diameter fitted with spacing washers giving any desired width of throat from ½-inch and 12 inches in variations of ½-inch. A novel feature of one of these machines is the arrangement of the vises or V-blocks for holding the work.

There are three of these, each 17 inches wide by 35 inches long with a capacity in the V's for stock up to 15 inches in diameter. The surfaces of these V-blocks are faced with steel. These V-blocks are fitted with swinging bolts arranged with open end strap clamps for convenience in inserting the work. In addition to the V-block, there is also a surface fitted with "T" slots for clamping the crankshaft, which is supported below by a jack having a bearing in the yoke fitted through the V-blocks. This jack screw has a ball and socket fit with a contact piece which permits of the use of the solid bearing under angular work.

The drive is through intermediate and worm gearing of a steep lead worm wheel of bronze and a worm of hardened steel, both running in oil from the armature shaft. The drive and quick traverse, while obtained from the motor shaft, are independent of each other. This permits of withdrawing the saw blades while not in motion, which is a desirable feature, as many times the unequal strain developing causes work to close on the saw blade, in which case rotation of the blade would cause the breakage of several teeth, while withdrawing them while stationary would only result in pulling the teeth from their sockets.

All the movements in the operation of the machine are controlled from one point. One lever controls the variation of feed, ranging from 0.35-inch to 2 inches per minute, and connects the driving clutch and also the quick return clutch. A very convenient feature is a scale and index mounted on the side of the machine, which gives the depth of the cut at any time.

The German cold sawing machine developed at Reutlingen, which is shown in the accompanying illustration, Fig. 5, is provided with electric drive and self-acting continuous speed and automatic stop as well as hand and power motion of the ram in both directions. The double cold sawing machine is provided with swivel heads, adjustable saw arbor and turn-table attachment, and was designed to cut the ends of long girders at any angles simultaneously or to cut short pieces independently while it is also utilized to make double miter cuts on the cold steel.

The adjustable saw arbors allow the use of rotary planer heads and of starting the cuts at any desired line. It has a total weight of 28,000 pounds and is operated by a 20 horse-power electric motor. It has a cutting capacity for steel 12 inches by 23 inches, the diameter of the saw blade being 40 inches.

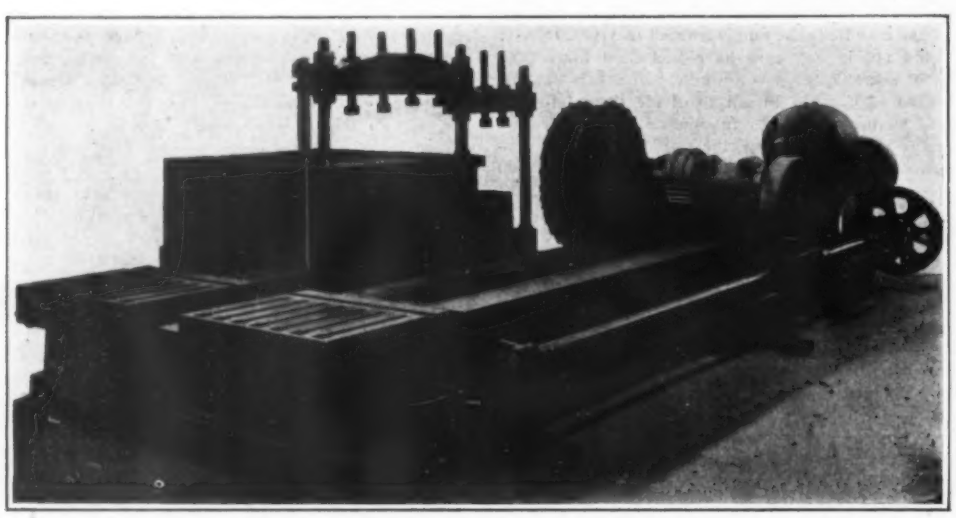


Fig. 4.—Electric cold saw built at Philadelphia, Pa.

The accompanying illustration, Fig. 6, shows another German cold sawing machine designed and constructed at Reutlingen. This cold sawing machine for double miter cuts weighs 25,000 pounds and requires for its operation an electric motor of 16 horse-power capacity. It has a saw blade 56 inches in diameter, and the machine occupies a floor space 160 by 180 inches.

It is provided with a vertical adjustment for the guide, thereby enabling the saw blade to be brought into the right position when cutting girder upright. The whole machine is mounted on a turn-table and can be set at any angle to the vise. By swinging the saw-head and the machine stand to the right position, miter cuts can be cut. The vise is mounted on a cast iron base and can be moved on guide rails close to the saw blade. The machine has electric drive continuous feed with automatic stop, and is fitted with hand and power movement for the ram in both directions.

The photograph, Fig. 2, shows a German double cold saw cutting a crankshaft, while in our frontis-piece may be seen the German development of a cold sawing machine with swivel head for steel castings. This machine has an adjustable saw arbor, flush side blade and quick return motion for the ram. The diameter of the blade is 40 inches and the speed revolutions per minute 140, while the length of drum on line shaft is 51¼ inches. It requires 10 horse-power and has a weight of 11,000 pounds.

The photograph, Fig. 3, shows the development of a Scotch horizontal band-sawing machine, and 36-inch cold sawing machine on turn-table base.

The Minervites

THE minervites are double phosphates of alumina and alkali that M. Armand Gautier discovered in 1892 in the grottoes of Minerva in the Herault Department. Since then they have been met with in diverse places, in the island of the Reunion, in the province of Oran, etc., but always in grottoes where primitively had become accumulated animal deposits and excrements, transformed first into guano, then into alkaline phosphates that have attacked the aluminous outer rock. These minervites are white substances, or else slightly tinted with yellow resembling kaolin, but containing 40 per cent of phosphoric acid and as much as 15 and 16 per cent of potash. It is easy to understand what a treasure and richness they would represent for agriculture if continuous banks of minervites were discovered. In the grotto of Minerva they are found in contact with the Permian red sandstone rocks in stratifications discordant with the nummuilitic. They there fill kinds of pockets to which is superposed a thick layer of earthy and clayey phosphates, among which are scattered very large quantities of the bones of the cave bears, of rhinoceros, of hyænas, of small gnawing animals, of bats, etc. The deposit discovered in 1892 by M. Armand Gautier represents not less than 100,000 tons of phosphated manure.—*Chemical News.*

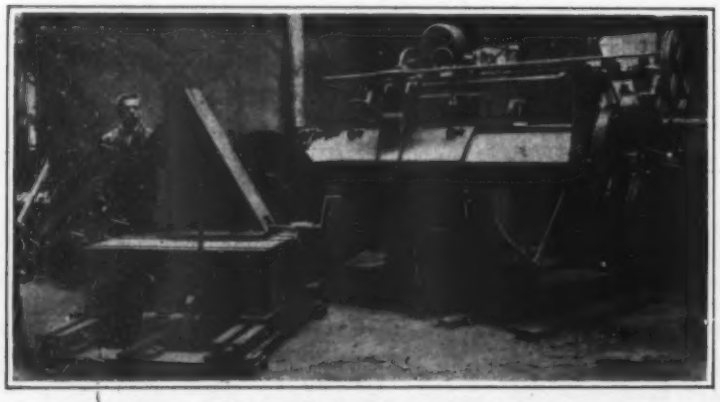


Fig. 5.—German electric cold saw for making double miter cuts.

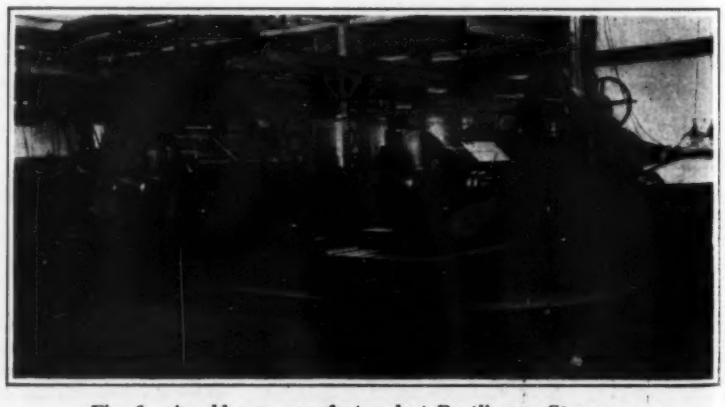


Fig. 6.—A cold saw manufactured at Reutlingen, Germany.

Series Discharge Tubes*

By Dr. H. Greinacher

If the terminals of a lightning arrester of the horn form are connected with the poles of a step transformer

Fig. 1.—Alternating discharge between horn electrodes.

or an induction coil fed with an alternating current, a luminous arc forms between the bases of the horns, travels upward to their summits, breaks, and instantly recommences at the bases. Although the ascent of the arc is comparatively slow, occupying about one second with a current of moderate strength, the separate partial discharges cannot be distinguished by the eye, but a photograph of the phenomenon shows a series of luminous trails starting alternately from each horn.

The partial discharges can be made separately visible by enclosing the horns in a glass vessel filled with rarefied air. In these conditions there is no arc, properly so-called, but each partial discharge produces a pointed bluish glow, and the successive positions of these luminous tongues, springing alternately from the right and left horn, or wire, can be followed directly with the eye. The blue glow always starts from the horn that at the moment is negative, and at the same instant a luminous red spot, called the anode light, appears opposite it on the other horn. The lively motion and brilliant colors of the discharge make it a very striking lecture illustration. It can be shown effectively by connecting the secondary wire of a small induction coil capable of giving an 8-inch spark, with the horns, and connecting the primary wire with an ordinary lighting circuit, furnishing an alternating current of 50 cycles per second.

The pressure of the air must be carefully regulated, as the most beautiful effects are obtained with a certain definite pressure. For this reason, it is advisable to use a glass tube of suitable dimensions, evacuated to the proper degree and sealed. The Gundalach firm, of Gehlberg, furnishes such tubes, filled with nitrogen, carbon dioxide, helium and many other gases, and also tubes provided with cocks, which may be exhausted by means of a water-jet pump, for the study of the discharge at different pressures.

These tubes not only form very welcome demonstration objects but also are useful for various practical purposes.

First. They can be used to determine the character of a current—whether alternating, intermittent direct, or continuous. Every variation in the form of the primary current shows in the succession of partial discharges, so that the series discharge tube constitutes an automatic oscillograph.

Second. The operation of direct current interrupters can be studied and regulated by means of these tubes. Even the extra current on closing the circuit can be detected. The number of interrupters per second can be determined by photographing the phenomenon and counting the number of partial discharges in one ascent of the arc, the time occupied in the ascent being noted.

Third. Short intervals of time can be measured by using as the primary an alternating current of known frequency. The time of exposure given by a camera shutter, for example, can be determined by focusing the camera

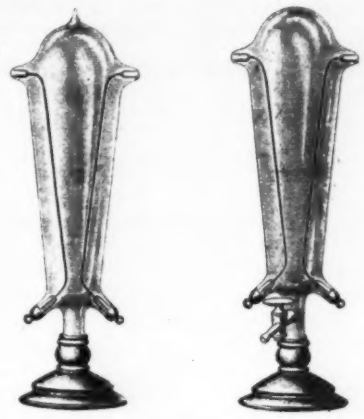


Fig. 2.—Horn electrodes in vacuum tubes.

on the tube and snapping the shutter while the discharge is passing. If the primary current is one of 50 cycles, or 100 alternations, per second, and 5 luminous tongues appear on the ground glass, the time of exposure is 0.05 second.

* Translated for the SCIENTIFIC AMERICAN SUPPLEMENT from *Elektrotechnische Zeitschrift*.

Fraudulent Playing Cards*

By Friedrich Januschke

In cheating at cards, as in playing the violin, no amount of practice can supply the place of genius. This fact was forcibly impressed upon me by an examination of some fraudulent cards in the criminal institute of the University of Graz. It appears impossible to acquire, by practice alone, skill in cheating with these cards, so slight and inconspicuous are the differences by which the backs of the cards are distinguished. Some degree of genius, or innate predisposition, is requisite for success.

I was confirmed in this opinion by experiments. I showed a pack of false cards to two men, pointing out all of the differentiating marks and explaining what they signified and how they were to be used. Then I asked the men to cheat me with these cards. One man soon succeeded in cheating me quite easily, without showing any evidence of intense thought or effort of memory, while the other experienced great difficulty in remembering the marks, and continually made mistakes.

Cards are marked in many different ways. For example, the king of hearts may bear a faint imprint of the finger nail at the middle of one side of the back, while the king of clubs is marked similarly at both sides, the king of diamonds at both sides and the top and the king of spades at both sides, top and bottom.

In another fraudulent pack the queens may be marked at the edges and the kings at the center. Markings more easily remembered than these are crossed nail imprints for the queen of spades (*kreuz*, or cross, is one of the German names for the spade suit), and two scratches, forming a V, or half diamond, for the queen of diamonds. One pack is marked very sparingly; another is overloaded with marks, as if it had been prepared by a person who distrusted his ability to differentiate the symbols. These nail imprints are felt and recognized by the finger tips, which often are prepared for the task by chemical treatment.

Other fraudulent cards bear lead pencil marks, usually in the form of dots, apparently so casual and unsystematic that it is very difficult to discover their significance. These pencil marks seem intended for the eye, as they are imperceptible to the touch, though it cannot be asserted with confidence that they cannot be felt by the sensitive fingers of the skilled gambler.

One pack of cards, definitely known to have been used for the purpose of cheating, appeared absolutely normal. It bore neither pencil marks nor nail imprints, and showed no evidence of artificial roughening of the edges by scraping with a knife, of perforation with a hot needle covered with melted wax (to fill the perforations) or of the removal of the glaze from any card.

It was a German skat pack of 32 cards. The backs were covered with the so-called "lightning" pattern, consisting of short and thick "zigzag" black and red lines, scattered irregularly over a white ground. Careful examination, however, revealed a peculiar figure which occupied a different position on the back of each card, except the four kings, on which it did not occur. The ends of this figure are indicated by the terminations of the lines *M* and *D*, which have been drawn across the photograph of one of the cards (Fig. 1).

When all of the cards were laid, face down, in four rows, according to suit and relative rank in skat, as is indicated in the diagram (Fig. 2), it became evident that the cards, while thus arranged, had been printed with a regularly recurring pattern, shorter and broader than themselves. The repeats of this pattern are bounded by the dotted lines in the diagram. The peculiar figure lies on the vertical dotted lines, and the diagram explains its absence from the kings and its varying position on the other cards.

It is evident, therefore, that this very talented swindler recognized the cards by the slight variations in the position of the pattern on their backs. There are two such packs in the criminal institute of the University of Graz and it may be assumed that other cards, as innocent in appearance as those of the "lightning" pattern, are equally well adapted for cheating and are successfully employed for that purpose.

* Adapted from *Die Umschau*.

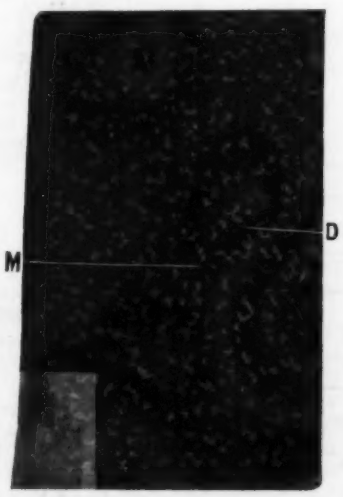


Fig. 1.—Back of card identified by peculiar pattern.

	Knave	Queen	King	Ace	X	IX	VIII	VII
Clubs								
Spades								
Diamonds								
Hearts								

Fig. 2.—Diagram explaining distinguishing pattern on card backs.

The Development of the Aeroplane—II*

What Experiment and Scientific Research Have Done for the Advancement of Aviation

By Dr. R. T. Glazebrook, F.R.S., F.Ae.S.

Concluded from SCIENTIFIC AMERICAN SUPPLEMENT No. 2005, Page 363, June 6, 1914

So far, we have been supposing the aeroplane to be in steady flight in a uniform wind. Let me remind you what the mathematics show will happen if it be disturbed from this condition.

DISTURBED FLIGHT IN A NON-UNIFORM WIND.

In the first place, we may deal separately with the motion of the machine in the vertical plane of symmetry, the longitudinal motion as it is called, and its lateral motion or motion perpendicular to that plane. If the longitudinal motion be slightly disturbed and the machine be stable, two kinds of oscillations are set up: one kind consists of rapid oscillations, both of the machine about its center of gravity and of the center of gravity itself. Ordinarily, in a stable machine, these are quickly damped down and give no trouble. But besides these the center of gravity of the machine itself describes an undulating path; the period of these undulations is much longer than in the first series, though for a stable machine the amplitude of the oscillation is gradually reduced and the machine, if no other changes have been made, gradually recovers its normal flight path. Mr. Lanchester has called these slower oscillations the phugoid oscillations.

If the machine is not stable, when disturbed from its normal path, its motion will diverge more and more from the condition of steady flight, and this divergence may take place continuously or it may happen that a series of oscillations of increasing amplitude is set up which ultimately become so large as to cause disaster. It is not possible to predict exactly what will happen in a given case without a knowledge of the relative values of the constants or coefficients already referred to, but if these be known the equations can be solved numerically and the details of the flight can be predicted.

We can go further than this, as Mr. Bairstow has shown in the beautiful model experiments he carried out recently before the Society, and determine the alterations which must be made in the machine to produce definite modifications in the conditions of its flight.

Now we have already seen in Figs. 7 and 8[1] the curves of forces and moments from which the constants can be determined for the model monoplane which has been exhibited. Mr. Bairstow and Mr. Nayler have recently determined the coefficients for this machine and used it to determine its motion under a variety of circumstances, and I propose to give some account of their results.

THE EFFECT OF A SINGLE HORIZONTAL GUST IN THE DIRECTION OF MOTION.

Let us suppose the machine is flying horizontally against a uniform wind and at a certain moment the horizontal velocity of the wind changes by a known amount, u_0 say, and remains permanently at its new value. What are the consequences to the machine? You may say at once, what is the use of doing this? It is rarely that an airman finds a perfectly steady wind in which to fly; it is practically impossible that that wind should change quite suddenly and remain steady with the new velocity. Real gusts are much more complex, why trouble about a purely hypothetical case? Well, but we must go slowly; we must walk before we run; step by step, line by line, here a little, there a little, is the way we must advance, and I shall hope to show you ere I close, how from the solution of some simple hypothetical cases we can obtain information as to what happens in actual flight.

Fig. 11 gives the solution of our problem; the longitudinal motion only is affected, and the results on the components of this motion are shown in the curves. The quantities we have to deal with are u, the change in the horizontal velocity relative to the surrounding air; w, the normal velocity, θ the pitch angle or angle of attack, and q the angular velocity of the machine in the plane of symmetry; q is of course equal to $\frac{d\theta}{dt}$.

At a certain moment, the velocity of the wind changes by an amount u_0. At that moment, therefore, the velocity of the aeroplane relative to the air is increased by an amount u_0, but this increase rapidly dies away, and after 5 seconds has become zero; the velocity goes on decreasing

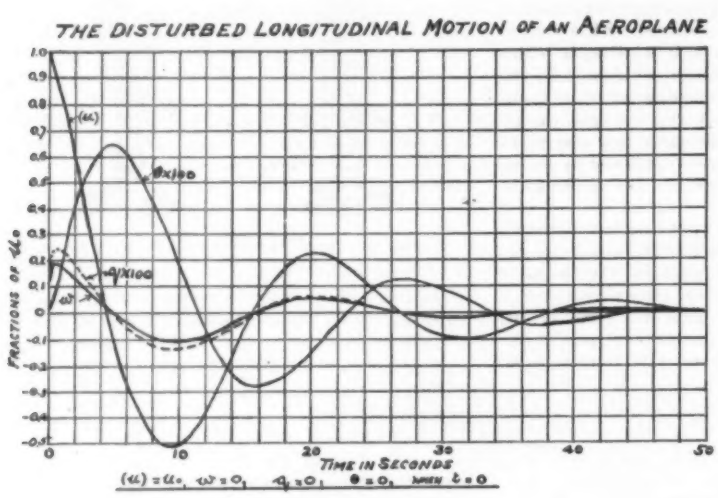


Fig. 11.

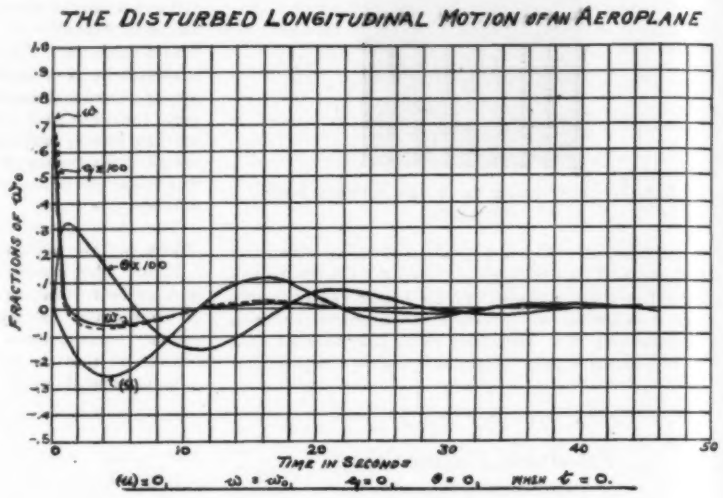


Fig. 12.

* The second Wilbur Wright Memorial Lecture, delivered at the Royal United Service Institution, Whitehall, on Wednesday May 20th, 1914.

[1] See SCIENTIFIC AMERICAN SUPPLEMENT, No. 2005, June 6th, 1914, page 363.

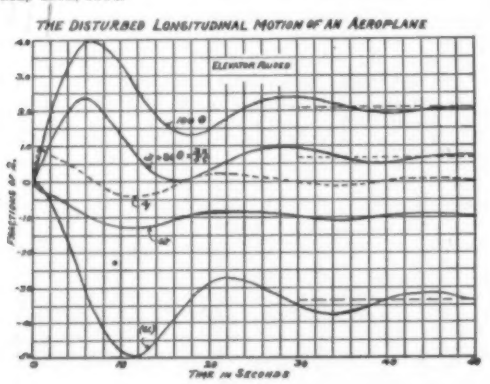


Fig. 13.

w = increase in upward velocity of aeroplane, and = w of mathematics. u = increase in velocity of relative wind, and = u of mathematics. θ = inclination of propeller axis to horizontal, as in mathematics. q = angular velocity turning machine from Z to X as in mathematics and when positive increases the inclination of propeller axis to horizontal.

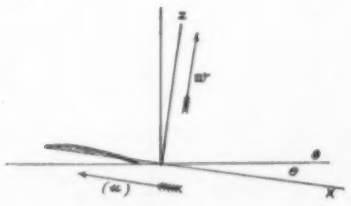


Fig. 13a.

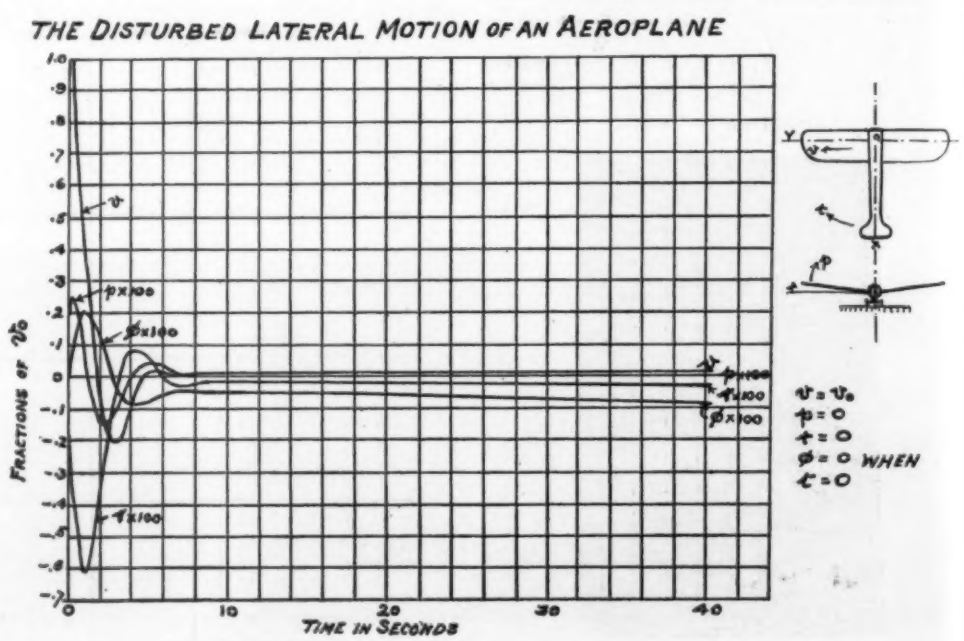


Fig. 14.

for 5 seconds more, and at the end of some 10 seconds has reached its minimum value, which is less than the original steady value by about $\frac{1}{4}u_0$. The velocity then increases again for some 10 or 11 seconds and the changes follow a regular periodic curve of rapidly decreasing amplitude, and after some 40 or 50 seconds are completely damped out. Dealing next with w, the normal velocity, we find it starts from zero, but rises rapidly in a fraction of a second to its maximum amount, about 2/10 of u, and then dies away rapidly in the same manner as u.

The angular velocity q is small, so small that the curve is drawn to give 100 times q, and this follows practically the same law as w, while θ, the pitch angle, increases for 5 seconds and then decreases to pass through period changes of decreasing amplitude and of about 22 seconds period.

The motion is stable; the complete calculations show that the rapid oscillations in this case only affect w and q, and that they die out in less than a second, while the other disturbances are those arising from the phugoid motion of the machine. Thus, in this case the machine when struck by the horizontal gust loses longitudinal speed at first and after passing through a series of changes of velocity, settles down after a few oscillations in less than a minute to its original speed relative to the wind. This loss of speed is accompanied by an initial increase of normal velocity; the machine rises for a fraction of a second, acquiring a rapid positive angular velocity, but these motions soon change sign and die away like the horizontal velocity. The nose of the machine rises for 5 seconds, at first rapidly, then more slowly, and this oscillation dies down in the same manner as the others.

A SINGLE DOWNWARD GUST IN THE PLANE OF SYMMETRY.

The next figure, Fig. 12, gives the changes due to a downward gust w. Relatively to the air the machine acquires an upward velocity w_0, which dies down in about one second and is followed by the slow phugoid changes as before. The changes in the other quantities are shown in the curves, and the motion of the machine can be traced as before.

By combining the results of these two diagrams we can find the effect of a steady gust striking the machine in any direction in the plane of symmetry. In a similar way we can find the effect of a change in the direction of the wind or of an alteration in the propeller thrust or of the position of the elevators. The last is shown in Fig. 13, in which it is supposed that the elevator is turned so as to cause the machine to dive.

LATERAL DISTURBANCE.

The next two figures indicate what the motion will be in two cases of lateral disturbance. This motion, in the particular machine dealt with, is unstable. Its expression involves three terms. One of these corresponds to a periodic oscillation rather heavily damped, having for one machine a period of about 6 seconds; the second to a considerable disturbance in certain of the co-ordinates, which however subsides or dies out very rapidly; and the third to a gradually increasing disturbance which gets larger with the time, according to an exponential law. The subsidence depends on terms such as $Ae^{-\lambda_1 t}$ and the divergence on terms involving $Be^{+\lambda_2 t}$, where λ_1, λ_2 are roots of a certain equation.

SIDE GUSTS.

In Fig. 14 is shown the effect of a side wind v_0 striking

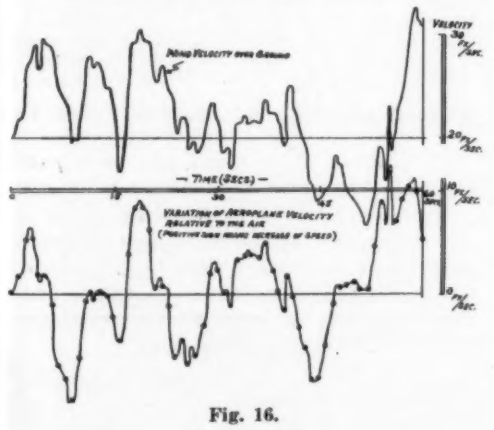


Fig. 16.

the machine on the left-hand side. The curves show chiefly the effect of the slow oscillation, though the rapid increase in the value of p, the velocity of rolling, is due to the subsidence term. The machine quickly picks up the velocity of the wind; after some 7 seconds v, the relative sideways motion, is very small, but it gradually increases, and after about 40 seconds has reached some 9 per cent of the original disturbance. Unless the controls are altered, the side-slip will continue to increase. A large angular velocity of roll p is started almost immediately, and at first this gradually dies down, but after 6 seconds or so the divergence term begins to tell and the rolling continues to increase unless checked by the pilot.

Again, r the velocity of yaw, is at first negative, the machine yaws to the left, a motion opposite to that which corresponds to the bank; after a time this is reversed and yaw and bank increase together.

SUDDEN "BANKING."

In Fig. 15 we have recorded the effect of sudden banking through an angle ϕ_0. The effects of the subsidence and oscillation terms are not large, but those of the divergence terms are very great; after 40 seconds the angle of banking exceeds its original value by 63 per cent, while r, the velocity of yaw. also increases rapidly, as does v, the side-slip velocity, which takes place in the negative direction. Thus, the machine turns to the right,

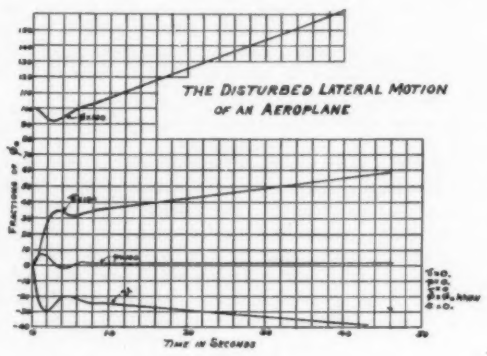


Fig. 15.

increasing the angle of banking and side-slipping outward and downward at the same time.

In all the descriptions above it has been assumed that the controls are not touched, but a comparison of Fig. 15 with the curve obtained when the effect of warping or of turning the rudder is considered, show that the control of such a machine is not easy.

Thus, Messrs. Bairstow and Nayler have solved the following problems: An aeroplane is in flight in the air—(1) At a given instant the wind changes either in speed or direction or both, and the new conditions remain for a time steady. The motion of the aeroplane is determined by the curves given in the paper; (2) at a given instant the controls of the aeroplane are altered. The ensuing motion is defined by other curves; and (3) by a suitable combination of the curves the effect of change of wind and change of control occurring simultaneously can be determined.

THE EFFECT OF SUCCESSIVE GUSTS.

They have however gone much further than this. The wind does not change instantaneously and remain steady. Let us investigate the effect of supposing that at the end of each consecutive second there is a change, but that during each second the wind is steady. Clearly this is a closer representation of the facts, and if we go further and take as our divisions of time, not seconds, but small fractions of a second, we get a proper representation.

We start with a knowledge of the motion of the aeroplane and the air at the commencement. Certain changes occur suddenly, and then for one second the atmospheric

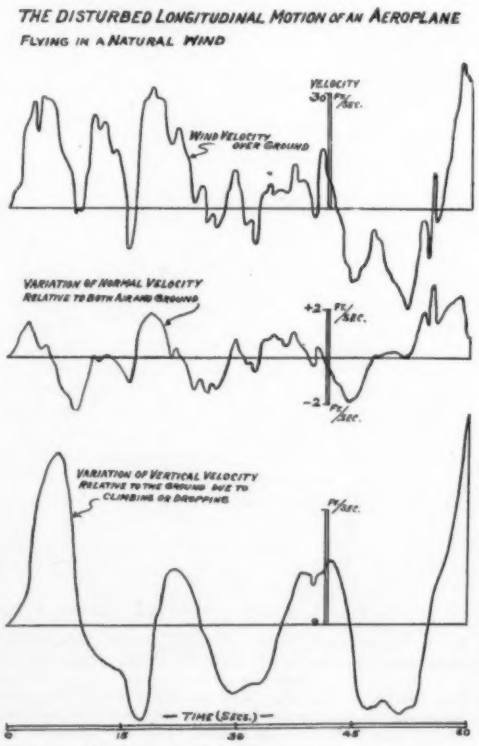


Fig. 17.

conditions remain steady. We can determine the motion of the aeroplane at the end of that second; then further atmospheric changes occur, treating the commencement of the second second as our origin of time, we know the motion of the aeroplane at that instant and our curves applied again will give it at the end of the second second, and we can proceed thus for each consecutive second and so find the resulting motion.

The operation is, of course, a very tedious one if the motion has to be investigated over any long period of time; its value consists in the fact that we can thus predict what will be the motion of an aeroplane having a definite amount of stability when moving in gusty air, if we analyze it thus for a few minutes, and we can thus determine whether either the safety of the machine or the comfort of the passenger requires a modification of the stability.

THE MOTION OF AN AEROPLANE IN A GUSTY WIND.

Now, for some experiments of Dr. Stanton, the variations of the horizontal velocity of the wind at the Kew Observatory were taken on a quick running anemograph and thus an open scale record of the velocity changes was obtained. The velocity ranged from 11 feet to 33 feet per second, the average being 20 feet per second, and an aeroplane moving with steady speed over the ground of, say, 60 foot seconds in the 20 foot seconds wind, meets this gust. Messrs. Bairstow and Nayler have analyzed this motion for a complete minute, assuming that the velocity of the wind changes at each second of the minute.

Figs. 16, 17 and 18 give the result. In Fig. 16, the upper curve shows the changes in the wind velocity during the minute. Starting at 20 feet, it rises suddenly for some 4 or 5 seconds, then there is a sudden drop, followed by an equally sudden rise, to drop again after some 8 or 9 seconds to the original 20 foot seconds and so on through the minute. The lower curve gives the variation in the velocity of the air relative to the machine during the same minute; the similarity of the two curves is marked.

The changes in air velocity relative to the aeroplane are much the same as those relative to the ground. The inertia of the machine and its small resistance prevent it from taking up the rapid changes in the air motion, and it feels the gusts much as though it were fixed. If we take the speed of the aeroplane over the ground in still air as 80 foot seconds, its speed relative to the gusty air varies from 70 to 94 foot seconds, while the speed of the air varies from 11 to 33 foot seconds. The aeroplane has not time to respond to the rapid changes. The attitude of the aeroplane to the wind alters during the time considered, it acquires a normal velocity at right angles to its own axis. The variations of this and of the vertical velocity relative to the ground are shown in Fig. 17. The top curve represents, as before, the changes in the wind velocity.

In Fig. 18 are shown the variations of the aeroplane velocity over the ground obtained by combining the two curves of Fig. 16, giving the variations of the velocity of the machine relative to the air and of the air relative to the ground, and also the variation in height of the aeroplane obtained from the vertical velocity curve of Fig. 17. While the changes in the actual horizontal velocity of the

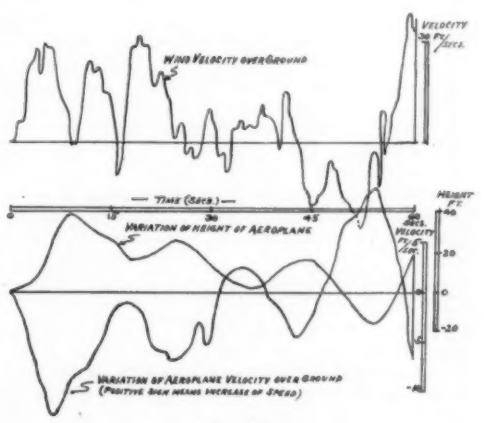


Fig. 18.

aeroplane are considerable they occur much more slowly than in the wind velocity curve, the minor alterations are wiped out; a rise in the wind velocity causes a fall in the velocity of the machine, provided the changes are sufficiently prolonged, but a very rapid rise and fall of the wind velocity is hardly noticeable. This aeroplane would take care of itself probably without undue discomfort to the pilot and without any manipulation of the controls in a gust such as is indicated, provided at least it had height in which to do it, but the changes of height involved are fairly considerable and amount, as will be seen from the figure, to rather over 60 feet in the course of the minute.

THE STRENGTH OF AEROPLANES.

There is another matter besides stability on which recent investigations throw considerable light. What are the stresses to which a machine may be subject in flight? How strong ought it to be made? What is a proper factor of safety to adopt? The matter has, during the past six months, received much attention from the Advisory Committee for Aeronautics. Let me briefly state some of the more important results; and first, what do we mean by the term factor of safety?

WHAT IS THE "FACTOR OF SAFETY"?

It is often used, I think, in aeronautical writings in a manner not quite consistent with that in which it is employed by engineers. The normal stress coming on any part of the machine is taken as that which it has to bear in steady horizontal flight, produced, that is, by a loading equal to the weight of the machine, and if the breaking stress is N times this, then N is called the factor of safety. But a machine in its ordinary use may frequently have to carry a load much in excess of that which it bears in steady horizontal flight. It would be more consistent with engineering practice to estimate as best we can what is the maximum stress the machine in its daily use may have to bear and then take as the factor of safety the ratio of the breaking stress to this maximum stress. The factor of safety would thus take account of imperfections of workmanship or of material, not of the varying load. Thus, if we suppose that the maximum stress we ought to allow for is that due to a loading equal to N_1 times the weight of the machine—the normal loading in horizontal flight—and that the breaking stress is n times this, so that n is the true factor of safety, then the ratio of the breaking stress to that occurring during steady horizontal flight is nN_1 and—calling this N, so that $N = nN_1$—then N and not n is the factor of safety as ordinarily (but I think mistakenly) used in aeronautics. The procedure gives a fictitious value to the factor of safety.

THE DETERMINATION OF THE MAXIMUM FLYING STRESSES.

The value of N has been determined by calculation and in some cases by direct experiment for a number of machines, and appears to range from three to seven. Let us consider briefly whether these figures are sufficient and ask ourselves in the first place what are the maximum stresses a machine may be expected to experience in flight and what value we ought to give to N_1, the ratio of these maximum stresses to those arising from the weight of the machine. We may perhaps call N_1 the load factor or factor of loading. Let us consider first a machine flying at its maximum speed, and suppose the speed range is equal to the minimum speed, so that the minimum speed is half the maximum. When flying at minimum speed the angle of attack is of course a large one, and the lift coefficient in this attitude must be four times as great as when flying at its maximum speed. This might mean that the angle of attack was increased from some 3 degrees to 12 degrees or 14 degrees, say through some 10 degrees. If such a change could take place suddenly before the machine had time to change its attitude and adapt itself to its new conditions, since the lift coefficient is increased four times and the velocity is unchanged, then for the moment the stresses thrown on the machine are four times as great as those it experiences in steady horizontal flight at maximum speed. Now experiments on vertical air currents are not very numerous, but direct experiment shows that upward velocities of 10 to 15 feet per second have been observed, and these, if suddenly experienced, might be sufficient to alter the angle of attack by some 10 degrees. Moreover, it appears possible that owing possibly to some obstacles or to the conformation of the ground the direction of the wind may alter—without change of speed—sufficiently in a distance comparable with a few lengths of an aeroplane to produce this change in the angle of attack. More careful investigation based on solutions of the equations of motion would give from three to four as the factor by which the loading may be increased, due to a sudden change in the angle at which the wind strikes the machine.

Another cause of serious sudden increase in loading is rapid flattening out after a dive.

Let us again take the case of a machine in which by an alteration of the angle of attack the lift coefficient may be increased in the ratio of 4 to 1. Calculation and in one or two cases observation have shown that it is possible for such a machine in a long steep dive to reach a speed approaching twice its maximum flying speed; the stresses are everywhere increased four times in consequence, since they vary as the square of the speed; suppose now the elevators are put over quite suddenly as far as possible so as to check the speed and bring the machine into the attitude relative to the air appropriate to minimum speed; the lift and hence the stresses are again increased fourfold. Thus, if this could be done instantaneously without gradually checking the speed, the stresses would be sixteen times those due to normal loading. Such sudden action is no doubt out of the question, but calculations, so far as it has been possible to carry them, show that stresses from eight to ten times those due to normal loading may be caused.

THE FACTOR REQUIRED IN ORDINARY FLYING.

Such high stresses of course do not occur in the ordinary conditions of flight if a machine is properly handled, and pilots should be careful never to allow the speed of their machines to exceed the maximum flying speed by more than 15 or 20 per cent and then only to put on the controls gently. I notice that Mr. Hucks, in a recent paper dealing with upside down flying, said that this was the instruction to which M. Blériot attached the greatest importance. It is clear then that it is essential to make an effort to strengthen machines so that they may bear the stresses due to six times the normal loading at least, and that even then occasions may occur in which this will be insufficient—occasions, that is, in which the real factor of safety will not exceed unity, even if it reaches that amount. An engineer would certainly think 2 too low a factor for his work, and this implies that if N_1 the possible load factor[1] be taken as 6 the value of N would be 12.

THE NEED FOR A HIGH STANDARD OF CONSTRUCTION AND OF PILOTING.

No doubt there are great difficulties in attempting to reach so high a value at present and indeed there are circumstances in which the advantages to be gained by saving weight cannot be neglected and which may always preclude its attainment. If it is not possible to secure that the machine cannot stand stresses more than six or eight times as great as those due to normal loading, all the more need is there for care in selecting the material and for skill in using it; all the more need for pilots to remember the conditions under which their machines are safe and to take care as far as possible to remain within the bounds set by those conditions. A prudent yachtsman does not sail his boat during the winter storms or risk its safety by an Atlantic passage; he knows its limitations. It may occasionally happen that a rapid dive and a sudden recovery are necessary, but these occasions are rare, and constructors can, I am confident, give our airmen machines which, if properly handled, have an ample margin of security.

I may be told I am asking for too high a standard. I am not capable of designing a machine and I have never flown, but I do not think the degree of safety I have specified is beyond our grasp, and I leave it to British manufacturers to reach it.

A man does not lose his reward either in this world or the next by setting a high ideal as the standard of his work and striving with his might to attain unto it. Wilbur Wright did that when he determined to fly.

[1] It should be noted that in calculating the stresses produced by a loading equal to say N_1 times the weight of the machine it is not sufficient to calculate them for the weight of the machine and multiply by N_1. The factor of loading N_1 must be settled before the calculations are begun and they must be made for a loading equal to N_1 times the weight. Moreover, allowance must be made for the motion of the center of pressure as the attitude of the machine varies.

Circuit-Breaker-Bell Alarm

M. E. MERRIMAN, writing to *Power*, says: Owing to the scattered arrangement of our power equipment and to various duties of the engineer calling him away from the engine room, it became necessary to install an alarm system of some kind which would call the attendant to the traveling-crane feeder panel whenever the circuit-breaker was tripped. We, therefore, devised the arrangement shown.

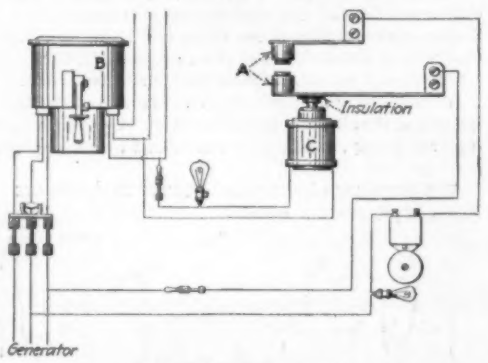


Diagram of alarm system.

An old 240-volt call bell, which had previously been used as a ground detector, was repaired and mounted in a convenient place where it could be easily heard from either of the two engine rooms or the fire room. It was connected to the generator side of the oil switch through a 120-volt lamp and carbon-tipped contacts *A*. These contacts were made by inserting small pieces of arc-light carbon into the brass terminal caps of an old 30-ampere cartridge fuse, leaving only about ½-inch of the carbon projecting. These caps were then soldered to pieces of thin spring brass and mounted on the wall near the oil switch *B* so that the carbons were about ½-inch apart. A small shunt-trip coil *C* taken from a discarded circuit-breaker was mounted, as shown, and connected through a 240-volt lamp to the line side of the oil switch. When the coil is energized, as when the main circuit is closed, the magnet plunger is drawn down and the spring of the brass mounting of the lower contact holds the contacts apart, thus breaking the bell circuit. When for any reason the oil switch is tripped, the shunt-trip coil is no longer energized and the plunger is expelled by a spring, forcing the carbon contacts together against the slight spring of the lower contact mounting, thus closing the alarm circuit which lights the 120-volt lamp and rings the call bell.

An Ingenious Method for Determining the Difference of Longitude

PROF. LIPPMANN has just discovered an exceedingly ingenious photographic method which enables the measuring of the difference of longitude existing between two localities. This method consists in taking simultaneously at each of the two stations a photograph of the sky, placing at the zenith an artificial star. By reducing these two photographs in the same way as is done for the photographic map of the sky, it is easy to calculate the difference of longitude to about a fraction of a second of an arc or segment, that is to say, with an uncertainty of merely scarcely 3 or 4 meters.—*Chemical News.*

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Table of Contents

	PAGE
Some Economic and Æsthetic Aspects of Electrochemistry.—By E. F. Roeber	370
Kinematograph in Research, The	371
Face and the Skull, The.—By Prof. Kollmann.—6 illustrations	372
Self-contained Portable Electric Mine Lamps.—By H. O. Swoboda.—11 illustrations	373
British Aeroplane Building	375
Microscopical and Colloidal Examinations of Jams.—By Ernest Marriage.—12 illustrations	375
Improvement in Radiotelegraphy and Radiotelephony.—III.—By W. H. Eccles.—5 illustrations	378
Protection of Battleships During Darkness	379
American and European Types of Electric Cold Saws, Some.—By Frank C. Perkins.—6 illustrations	380
Series Discharge Tubes.—By Dr. H. Greinacher.—3 illustrations	381
Fraudulent Playing Cards.—By Friedrich Januschke.—2 illustrations	381
Development of the Aeroplane, The.—II.—By Dr. R. T. Glazebrook.—9 illustrations	382
Circuit-breaker-bell Alarm.—1 illustration	384

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	PAGE
	370
	371
	372
	373
	375
	375
	378
	379
	380
	381
	382
	384